AD-A081 743    FLEET NUMERICAL WEATHER CENTRAL MONTEREY CA    F/G 8/10

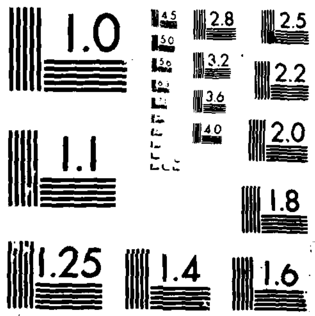
AVERAGE WINTER AND SUMMER TEMPERATURE AND SALINITY PROFILES FOR--ETC(U)

AUG 68  E HASHIMOTO

UNCLASSIFIED    FNWC-TN-41    NL

1 OF 1
AD
A081743

END
DATE
FILMED
4-80
DTIC




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Technical Note No. 41



August 1968



# AVERAGE WINTER AND SUMMER TEMPERATURE AND SALINITY PROFILES FOR THE DEEP OCEAN PROVINCES



By

E. HASHIMOTO



FLEET NUMERICAL WEATHER CENTRAL

MONTEREY, CALIFORNIA

(6) AVERAGE WINTER AND SUMMER TEMPERATURE AND SALINITY PROFILES FOR THE DEEP OCEAN PROVINCES.

(9) Technical notes

(14) FNWC-TN-41

(11) Aug 68

(12) 49

(10) By

E. HASHIMOTO

Letter on file

A 23

138670

CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## Abstract

The oceans of the northern hemisphere are divided into twenty-three different provinces. For each province mean temperature and salinity structures are given from surface to bottom. For the upper part of the temperature profile winter and summer conditions are given. Furthermore, average maximum and minimum temperature profiles for the upper 400 meters are given for each of the regions. The formation of the temperature and salinity profiles in a number of regions is briefly described and few comparisons of the regions are made.

## 1. Introduction

The purpose of this paper is to present winter and summer average temperature and salinity profiles for the ocean provinces in the northern hemisphere oceanic regions or provinces in which the environmental conditions would be considered relatively uniform.

The divisions of the ocean into natural regions is not new. The surface waters have been divided into natural regions earlier by Schott (1935, 1942), Dietrich (1956) and by Hela and Laevastu (1962). Attempts have been made to divide the deep ocean basins into different provinces. Sverdrup (in Sverdrup, Johnson and Fleming, 1942) has classified different deep water masses by the temperature-salinity (T-S) diagrams of Helland-Hansen. The present work intends to combine both the surface regions and deep ocean basins into so-called ocean provinces. This division has been dictated by a number of practical considerations such as sound propagation estimations.

It is obvious that the spatial variability within a region from one province to another exists; furthermore, there are no sharp boundaries in the ocean. Therefore, one has to consider the transition regions as being the boundary zones between the different provinces.

The data for the deep ocean thermal and salinity structure have been taken from available Nansen cast data. The data for the upper 150 meters originate from analyses made by Mrs. M. Robinson at S.I.O..

Acknowledgement: This work has been performed under the guidance of Dr. T. Laevastu. Some of the profiles have been extracted from the available data by Mr. P. D. Stevens, whose assistance in preparing this paper is gratefully acknowledged.

## 2. Formation of water masses and types

The surface water types are defined by temperature and salinity and by their annual changes in the surface layers down to depths of 150-200 meters. These surface types are subject to relatively large seasonal changes in most regions. Below 200 meters the temperature and salinity relations are only changed slowly and they are customarily called water masses. The T-S diagrams have been used in the past to define the water masses. This concept has been used to some extent in this work, but more emphasis has been put on the thermal and salinity structure with depth for dividing the ocean into the provinces given in this paper.

The major natural provinces are separated by bands of water which will be referred to as "transition regions". Transition regions will vary from well-defined to undefinable since they constitute a dynamic front or a current boundary (Clarke and Laevastu, 1966). Figure 25 gives the natural provinces as well as the transition regions.

There are several factors which influence and determine the physical characteristics of a water mass. The factors are: latitude of the region, the types of currents, runoff, evaporation, precipitation and heat exchange.

The annual cycle of heating and cooling in medium and high latitudes is one of the most significant factors in determining the water type properties of the provinces at those latitudes. The seasonal changes are relatively small at lower latitudes and in so-called upwelling regions. There are some annual salinity changes and these changes are relatively small in most areas. Furthermore, the salinity is less important in sound propagation than the effects of temperature; therefore, only one salinity profile for each region is given in this paper. The boundaries between the provinces are very often the boundaries

of the current systems (meaning the divergence and convergence of currents). The boundaries fluctuate somewhat seasonally and also in shorter periods. Therefore, the transition regions have been indicated on Figure 25 as relatively wide although in synoptic situations they may be considerably narrow. The properties of the deeper layers, determined to a large extent by the bathymetry of the ocean's basins which are separated by sills, usually have slightly different temperature and salinity structures. Furthermore, such features as the Mediterranean outflow over the Gibraltar sill and the outflow from the Norwegian Sea through the Faeroe-Shetland channel influence the properties of the deeper waters outside those semi-closed basins. The deeper water masses themselves are formed at high latitudes. Most of the intermediate and deep waters are formed around the Arctic and spread toward the north in both oceans. However, some deep water is formed in the North Atlantic especially in the eastern part of the Greenland Sea during the winter, and possibly some intermediate water is formed in the western part of the Irminger Sea. The intermediate waters from 900-1500 meters in the Iberian region are formed by the addition of the high salinity, warmer Mediterranean water which flows over the Gibraltar sill. The deep waters on both sides of the mid-Atlantic ridge obviously are different from each other.

Nearly no bottom water is formed in the North Pacific, though some intermediate water is formed in the Oyashio region and possibly off the Japanese islands. Some specific intermediate water for the upper layers with low salinity and low temperature is formed in the Oyashio region, spreads out over considerable parts of the Pacific and forms the so-called sub-thermocline duct. Furthermore, intermediate warmer waters are formed in anti-cyclone gyrals in the Sargasso Sea (so-called 18 degree water) and east of the Japanese islands in the Kuroshio

gyral (so-called 15 degree water). The intermediate layers are also modified by upwelling in upwelling regions like that off California and another similar region off Morocco.

3. Ocean provinces and temperature and salinity profiles

The oceanic provinces are shown on Figure 25. The temperature and salinity profiles are shown in Figures 1 through 24. The temperature profiles are in two different depth and temperature scales. The surface layers from 0-300 meters are shown in an insert. In this insert the winter and summer means are shown with heavy full-drawn lines for winter and heavy dotted lines are drawn for summer. The thin full lines refer to the northern most part of that region during the winter, and the thin dotted lines refer to the southern most part of that region during the summer. Both of these extremes are also means rather than absolute extremes. It has been attempted to make the profiles typical and synoptic rather than as mean profiles; thus the mixed layer depth (MLD) and the gradients have been depicted as they occur frequently in synoptic observations from these regions.

The names of the provinces given on Figure 25 are shown on Table I:

NORTH PACIFIC PROVINCES

| Area | Names* |
|---|---|
| A | California region |
| B | California current extension region |
| C | East sub-tropical region |
| D | Alaska gyral region |
| E | Central tropical region |
| F | North sub-Arctic region |
| G | North equatorial current region |

NORTH PACIFIC PROVINCES (continued)

| Area | Names* |
|---|---|
| H | West sub-tropical region |
| I | Sea of Japan |
| J | Philippine Sea |
| K | North China Sea |
| L | South China Sea |

SOUTH ATLANTIC PROVINCES

| Area | Names* |
|---|---|
| O | Sargasso Sea |
| P | Central Atlantic |
| Q | North West Atlantic |
| R | Transition region between South Iberian and North Equatorial |
| S | South Iberian region |
| T | North Iberian region |
| U | North East Atlantic region |
| V | Greenland Sea |
| W | North Sea |
| X | Norwegian Sea |
| Y | West Mediterranean |
| Z | East Mediterranean |

*(Hela-Laevastu, 1962) - the names have been modified to accommodate the deep waters.

TABLE I

## 4. Some comparisons of deep ocean provinces

In the breakdown of the twelve provinces according to their surface temperature ranges, a geographical relationship appears to be evident. The following chart illustrates this possibility:

NORTH PACIFIC OCEAN

| Group | Surface temperature range | Provinces (see Fig.25) | Latitude |
|---|---|---|---|
| A | 14.2 to 27.5 | A, B, G, J, L | 15N to 25N |
| B | 11.0 to 17.0 | C, E, H, K | 25N to 40N |
| C | 1.5 to 5.0 | D, F, I | 40N to 50N |

A similar breakdown of the North Atlantic provinces was charted as follows:

NORTH ATLANTIC OCEAN

| Group | Surface temperature range | Provinces (see Fig.25) | Latitude |
|---|---|---|---|
| A | 14.8 to 19.0 | O, P, R, S | 25N to 40N |
| B | 8.3 to 13.7 | T, U, Y | 40N to 55N |
| C | 0.0 to 7.0 | Q, V, W, X | above 55N |

The North Atlantic Ocean, unlike the North Pacific Ocean, possesses topographic features which appear to be significant in the geographical positioning of the water masses.

The North Pacific exhibits a wider variability in surface temperatures. For both oceans, the maximum values of surface temperatures occur in the North Pacific and the minimum surface temperature values occur in the North Atlantic. In all twenty-four regions as temperature values in the upper levels increase from winter to summer the mixed layer depths become shallower and the gradients increase. By comparing the conservative factors of the deep bottom waters of both oceans, the North Pacific Bottom Water appears to possess a more distinct characteristic ($T^{\circ}C=1.4$ to $1.8, S‰$ 34.66 to 34.74).

Analyzing the bottom water for both the North Pacific and North Atlantic Oceans, several distinct features are present among their respective temperature and salinity profiles. In general, the following were determined:

(a) In the salinity profiles of the North Pacific provinces, salinity minimums occur above 1000 meters. Salinity values from the surface to 7000 meters range roughly between 33.00 to 35.75 parts per 1000. In the salinity profiles of the North Atlantic, with the exception of the Mediterranean provinces, salinity maximums occur at or near the surface and the values from the surface to 7000 meters range approximately between 34.80 to 36.65 parts per 1000. The bulges (minimums) occurring in the salinity profiles of the North Pacific provinces are due to the presence of the North Pacific Intermediate Water.

(b) In the North Atlantic, with the exception of the Mediterranean provinces, salinity values between 34.89 to 34.95 parts per 1000 and temperature values between -0.4 to 2.5°C occur in every profile below 2500 meters. This distinct feature may represent the North Atlantic Deep Bottom Water.

(c) The deep waters of the North Atlantic provinces are nearly isothermal below 4000 meters and nearly isohaline below 2500 meters. The deep waters of the North Pacific provinces are nearly isothermal and nearly isohaline below 3000 meters. This infers that the deep bottom waters of the North Pacific are more homogeneous than those of the North Atlantic.

(d) Very high salinity values exist in the Mediterranean provinces due to their isolation from the Atlantic circulation. In both the

Mediterranean provinces (Y and Z) the less saline water blankets the more saline water. Atlantic inflow, precipitation and river run-off will cause the surface layers to possess lower salinity values. A salinity maximum is a distinct feature between 250 and 600 meters. The variations in the winter and also in the summer temperature profiles vary only slightly; below 150 meters the temperature profile is nearly constant year around.

A series of tables has been prepared to enable the reader to receive approximate values for the following: winter and summer variations of temperature in $^{\circ}C$, the mixed layer depth (MLD) variations (meters), the thermal gradients ($^{\circ}C/30$ meters), the salinity range (parts per 1000), the salinity gradients (parts per 1000 per 100 meters) and comments. The values which appear on the tables were taken directly from the temperature and salinity profiles (Areas (A) to (L), and Areas (O) to (Z)).

# REFERENCES


Clarke, L.C., and Laevastu, T.- Numerical Methods for Synoptic Computation of Oceanic Fronts and Water Type Boundaries and Their Significance in Applied Oceanography. FNWF Technical Note No. 20
1966

Dietrich, G., - General Oceanography, Interscience Publishers, New York.
1963

Fairbridge, Rhodes W. - The Encyclopedia of Oceanography, Reinhold Publishing Corporation, New York, Vol. 1.
1966

Hela, I. and Laevastu, T. - Fisheries Hydrography, Fishing News Books Ltd., London.
1962

Schott, G., - Geographie des Indischen und stillen Ozeans, Ver lag Von C. Boysen, Hamburg.
1935

Schott, G., - Geographie des Atlantischen Ozeans, Ostern, Hamburg.
1942

Sverdrup, Johnson and Fleming - The Oceans, Prentice Hall, Inc., New York pp. (141-150), pp 605-755).
1942

SURFACE

| AREA | WINTER VARIATION ($T^oC$) | MLD* (m) | GRADIENT@ ($^oC/30m$) | SUMMER VARIATION ($T^oC$) | MLD* (m) | GRADIENT@ ($^oC/30m$) |
|---|---|---|---|---|---|---|
| A | 14.2-17.8 | 68-80 | 3.1 | 21.2-24.0 | 30-37 | 4.6 |
| B | 19.8-23.4 | 117-70 | 2.0 | 25.0-26.0 | 70-64 | 3.6 |
| C | 12.4-16.0 | 100 | 1.2 | 22.0-24.8 | 30-50 | 4.5 |
| D | 3.8-5.0 | 130-115 | 0.4 | 12.5-15.8 | 20-22 | 4.2 |
| E | 12.0-16.0 | 130 | 1.4 | 25.0-26.0 | 20-40 | 6.8 |
| F | 1.5-3.8 | 134-82 | 0.3 | 11.0-13.6 | 20-15 | 6.5 |
| G | 23.6-24.5 | 110-115 | 1.6 | 29.0-30.0 | 40-54 | 2.6 |
| H | 11.0-17.0 | 158-150 | 1.8 | 27.5-28.7 | 30-27 | 5.6 |
| I | 2.0-4.0 | 194-123 | 1.7 | 18.0-26.0 | 20-40 | 9.8 |
| J | 20.8-27.5 | 115-70 | 2.6 | 29.0-30.4 | 38 | 1.6 |
| K | 13.0-14.0 | 60-100 | 1.2 | 27.0-28.3 | 15-25 | 5.0 |
| L | 20.0-25.0 | 40 | 2.8 | 29.0-30.4 | 30 | 3.0 |

* Values of MLD correspond to temperature variations, respectively.
@Values for gradient were taken from first 30 meters following MLD.

TABLE IIa : Winter and summer temperatures, mixed layer depths and vertical temperature gradients ($^oC/30$ meters) for the Pacific provinces.

SURFACE TO 400 METERS

| AREA | WINTER SALINITY (S 0/00) | | GRADIENT** (0/00/100m) | SUMMER SALINITY (S 0/00) | | GRADIENT** (0/00/100m) | COMMENT |
|---|---|---|---|---|---|---|---|
| A | Sfc to 100m | 33.75 | 0.25 | Sfc to 40m | 34.00 | 0.61 | Summer curve joins main curve at 70m at 33.75 |
| B | Sfc to 60m | 34.67 | 0.43 | | | | |
| C | Sfc to 100m | 34.25 | 0.16 | | | | |
| D | Sfc to 80m | 33.12 | 0.42 | Sfc to 10m | 32.82 | 0.35 | Summer curve joins main curve at 110m at 33.20 |
| E | Sfc to 110m | 34.60 | 0.19 | Sfc to 70m | 34.70 | 0.20 | Summer curve joins main curve at 110m at 33.17 |
| F | Sfc to 130m | 33.30 | 0.36 | Sfc to 10m | 33.10 | 0.54 | Summer curve joins main curve at 325m at 34.06 |
| G | Sfc to 100m | 35.05 | 0.23 | | | | Salinity maximum at approximately 150m at 35.10 |
| H | Sfc to 200m | 34.75 | 0.11 | | | | |
| I | Sfc to 150m | 34.17 | 0.07 | | | | |
| J | Sfc to 60m | 34.62 | 0.26 | | | | Salinity maximum at approximately 160m at 34.92 |
| K | Sfc to 160m | 33.00 | 0.42 | Sfc to 45m | 32.00 | 1.48 | |
| L | Sfc to 60m | 34.15 | 0.30 | | | | Secondary salinity max. at approx. 220m at 34.48 |

** Salinity gradients were taken from first 100 meters after surface isohaline inflection
S 0/00 = parts per thousand

TABLE IIb

400 to 1200 METERS

| AREA | RANGE ($T^{o}C$) | GRADIENT@@ ($^{o}C/100m$) | RANGE (S 0/00) | GRADIENT@@ (0/00/100m) | COMMENT |
|---|---|---|---|---|---|
| A | 3.7-8.0 | 0.9 | 34.40-34.61 | 0.12 | |
| B | 3.6-8.1 | 2.1 | 34.21-34.62 | 0.11 | |
| C | 3.0-7.9 | 1.6 | 34.00-34.52 | 0.02 | Salinity minimum at approximately 420m at 32.00 |
| D | 2.4-3.6 | 0.2 | 34.12-34.53 | 0.07 | |
| E | 2.8-9.3 | 1.9 | 34.11-34.42 | 0.08 | Salinity minimum at approximately 600m at 34.00 |
| F | 2.4-3.3 | 0.1 | 34.12-34.50 | 0.09 | |
| G | 3.0-12.4 | 3.2 | 34.41-34.53 | 0.19 | Salinity minimum at approximately 600m at 34.21 |
| H | 3.2-14.7 | 1.1 | 34.61-34.53 | 0.21 | Salinity minimum at approximately 750m at 34.05 |
| I | 0.0-0.7 | 0.3 | | 0.00 | Nearly isohaline from 200m at 34.11 |
| J | 3.0-9.0 | 2.0 | 34.32-34.60 | 0.03 | Salinity minimum at approximately 500m at 34.28 |
| K | | | | | $T^{o}C$ data above 300m S 0/00 data above 400m |
| L | 3.7-9.8 | 1.8 | 34.41-34.61 | 0.02 | Small salinity min. at approximately 550m at 34.33 |

@@ Temperature and salinity gradients were taken from 400 meters to 500 meters.
S 0/00 = parts per thousand

TABLE IIc

## 1200 TO 7000 METERS

| AREA | RANGE ($T^{o}C$) | RANGE (S0/00) | COMMENT |
|---|---|---|---|
| A | 1.8-3.8 | 1200m to 3250m<br>34.63 to 34.70 | Nearly isothermal from 3000m at 1.8°C<br>Nearly isohaline from 3250m at 34.70 |
| B | 1.7-3.7 | 1200m to 2000m<br>34.60 to 34.65 | Nearly isothermal from 3000m at 1.7°C<br>Nearly isohaline from 2000m at 34.65 |
| C | 1.7-3.0 | 1200m to 2000m<br>34.47 to 34.60 | Nearly isothermal from 2500m at 1.7°C<br>Nearly isohaline from 3500m at 34.60 |
| D | 1.6-2.4 | 1200m to 3500m<br>34.50 to 34.70 | Nearly isothermal from 3000m at 1.6°C<br>Nearly isohaline from 3500m at 34.70 |
| E | 1.6-2.8 | 1200m to 2500m<br>34.42 to 34.75 | Nearly isothermal from 3000m at 1.6°C<br>Nearly isohaline from 2500 at 34.75 |
| F | 1.4-2.4 | 1200m to 2500m<br>34.50 to 34.68 | Nearly isothermal from 2750m at 1.4°C<br>Nearly isohaline from 3000 at 34.68 |
| G | 1.6-3.1 | 1200m to 2500m<br>34.50 to 34.65 | Nearly isothermal from 2500m at 1.6°C<br>Nearly isohaline from 3500m at 34.65 |
| H | 1.6-3.2 | 1200m to 2500m<br>34.35 to 34.64 | Nearly isothermal from 3000m at 1.6°C<br>Nearly isohaline from 3500m at 34.70 |
| I | 0.0 | 34.10 | Nearly isothermal from 1000m at 0.0°C<br>Nearly isohaline from 200m at 34.10 |
| J | 1.8-3.0 | 1200m to 3000m<br>34.55 to 34.65 | Nearly isothermal from 2500m at 1.8°C<br>Nearly isohaline from 3000m at 34.65 |
| K | | | $T^{o}C$ data from above 300m<br>S 0/00 data from above 400m |
| L | 2.0-3.7 | 1200m to 2000m<br>34.57 to 34.62 | Nearly isothermal from 2750m at 2.0°C<br>Nearly isohaline from 2000m at 34.62 |

TABLE IId

SURFACE

| AREA | WINTER VARIATION ($T^oC$) | MLD* (m) | GRADIENT@ ($^oC$/30m) | SUMMER VARIATION ($T^oC$) | MLD* (m) | GRADIENT@ ($^oC$/30m) |
|---|---|---|---|---|---|---|
| O | 16.0-19.0 | 130 | 0.5 | 26.5-27.8 | 22-40 | 2.6 |
| P | 14.8-16.4 | 167-170 | 0.9 | 24.0-26.3 | 12-40 | 4.0 |
| Q | 1.0-3.9 | > 300 | 0.1 | 9.0-11.2 | 30 | 2.0 |
| R | 18.0-19.0 | 110-90 | 0.4 | 22.8-23.8 | 30-40 | 2.4 |
| S | 15.3-17.0 | 137-80 | 0.5 | 22.0-24.5 | 35-30 | 2.7 |
| T | 11.6-12.4 | 180-225 | 0.2 | 20.0-21.4 | 20-37 | 3.8 |
| U | 8.3-10.4 | 140-160 | 0.4 | 15.8-17.1 | 30-33 | 2.2 |
| V | 0.2-0.4 | > 80 | 0.1 | 4.4-5.6 | 22-30 | 2.6 |
| W[1] | 4.8-5.2 | 100-20 | nearly isothermal | 15.0-16.0 | 20-40 | 6.4 |
| X | 3.0-7.0 | 90-200 | 0.8 | 10.5-11.6 | 32-35 | 2.7 |
| Y | 10.0-13.7 | 110-300 | 0.7 | 22.0-23.0 | 25-28 | 6.4 |
| Z | 14.0-15.7 | 170-100 | 0.5 | 25.8-26.8 | 12-17 | 6.4 |

* Values of MLD correspond to temperature variations respectively.
@Values for gradient were taken from first 30 meters following MLD.

[1] Temperature maximum at approximately 40m at 6.0$^oC$

TABLE IIIa: Winter and summer temperatures, mixed layer depths and vertical temperature gradient ($^oC$/30 meters) for the Atlantic provinces.

SURFACE TO 400 METERS

| AREA | WINTER SALINITY (S 0/00) | GRADIENT** (0/00/100m) | SUMMER SALINITY (S 0/00) | GRADIENT** (0/00/100m) | COMMENT |
|---|---|---|---|---|---|
| O | Sfc to 220m 36.40 | 0.21 | | | |
| P | Sfc to 400m 36.00 | 0.05 | | | |
| Q | Sfc to 240m 34.75 | 0.52 | Sfc to 40m 34.27 | 4.51 | |
| R | Sfc to 100m 36.25 | 0.11 | | | |
| S | Sfc to 100m 36.70 | 0.12 | | | |
| T | Sfc to 160m 35.65 | 0.10 | | | |
| U | Sfc to 160m 35.55 | 0.13 | Sfc to 25m 35.40 | 0.15 | Summer curve joins main curve at 60 meters |
| V | Sfc to 400m 34.95 | 0.04 | | | |
| W | Sfc to 180m 35.15 | nearly isohaline | Sfc to 25m 34.90<br>25m to 75m 35.50 | 0.30 | |
| X | Sfc to 150m 35.10 | 0.12 | Sfc to 60m 35.21 | 0.14 | Summer curve joins main curve at 150 meters |
| Y | Sfc to 120m 37.90 | 0.19 | | | |
| Z | Sfc to 80m 38.25 | 0.41 | | | |

** Salinity gradients were taken from first 100 meters after surface isohaline inflection.
S 0/00 = parts per thousand

TABLE IIIb

400 to 1200 METERS

| AREA | RANGE (T°C) | GRADIENT@@ (°C/100m) | RANGE (S 0/00) | GRADIENT@@ (0/00/100m) | COMMENT |
|---|---|---|---|---|---|
| O | 5.0-17.2 | 0.93 | 400m to 1200m<br>36.15 to 35.06 | 0.28 | |
| P | 4.3-15.2 | 0.33 | 400m to 1200m<br>36.00 to 35.08 | 0.03 | |
| Q | 3.3-3.8 | 0.12 | 400m to 1200m<br>34.73 to 34.85 | 0.05 | Nearly isohaline |
| R | 4.8-15.3 | 1.62 | 400m to 800m<br>36.10 to 35.95<br>800m to 1200m<br>35.24 to 34.93 | 0.06 | |
| S | 8.6-12.3 | 0.23 | 400m to 1200m<br>35.55 to 35.65 | 0.10 | Secondary salinity<br>max. at approx.<br>1250m at 35.65<br>(Mediterranean Ext.) |
| T | 7.6-11.9 | 0.12 | 400m to 1200m<br>35.52 to 35.47 | 0.0[illegible]<br>(nearly<br>isohaline) | Secondary salinity<br>max. at approx.<br>900m at 35.60<br>(Mediterranean Ext.) |
| U | 4.6-9.6 | 0.15 | 400m to 600m<br>35.41 to 35.23 | 0.04 | Nearly isohaline<br>from approximately<br>600m at 35.23 |
| V | (-0.4)-(-0.2) | 0.03 | 400m to 1200m<br>34.95 to 34.92 | 0.02 | Nearly isothermal<br>from 700m at -0.4<br>Nearly isohaline |
| W | | | | | T C and S 0/00 data<br>above 100 meters |
| X | 0.0-3.6 | 0.27 | 400m to 1200m<br>34.92 | nearly<br>isohaline | Nearly isohaline<br>from approx. 420m<br>to 7000 at 34.90 |
| Y | 12.9-13.6 | 0.03 | 400m to 500m<br>38.41 to 38.52<br>600m to 1000m<br>38.52 to 38.40 | 0.06 | Salinity maximum<br>at approximately<br>550m at 38.52<br>Evap > ppt.+ runoff |
| Z | 13.5-13.8 | 0.02 | 400m to 1200m<br>38.75 to 38.62 | 0.03 | Nearly isohaline<br>High salinity due to<br>Evap./ppt+runoff |

@@ Temperature and salinity gradients were taken from 400 meters to 500 meters.
S 0/00 = parts per thousand

TABLE IIIc

1200 TO 7000 METERS

| AREA | RANGE ($T^{O}C$) | RANGE (S0/00) | COMMENT |
|---|---|---|---|
| O | 2.2-5.0 | 1200m to 7000m<br>35.05 to 34.90 | Nearly isothermal from 4000m at 2.2°C<br>Nearly isohaline from 2000m at 34.90 |
| P | 2.1-5.4 | 1200m to 7000m<br>35.07 to 34.90 | Nearly isothermal from 4000m at 2.1°C<br>Nearly isohaline from 3000m at 34.90 |
| Q | 2.1-3.3 | 1200m to 7000m<br>34.86 to 34.90 | Nearly isothermal from 4250m at 2.1°C<br>Nearly isohaline from 2000m at 34.90 |
| R | 2.3-4.8 | 1200m to 7000m<br>34.92 to 34.90 | Nearly isothermal from 5000m at 2.3°C<br>Nearly isohaline from 1300m at 34.90 |
| S | 2.4-8.6 | 1250m to 7000m<br>35.40 to 34.95 | Nearly isothermal from 4000m at 2.4°C<br>Nearly isohaline from 2500m at 34.95 |
| T | 2.5-7.6 | 400m to 7000m<br>35.49 to 34.90 | Nearly isothermal from 4000m at 2.5°C<br>Nearly isohaline from 2500m at 34.90 |
| U | 2.5-4.6 | 400m to 7000m<br>35.20 to 35.17 | Nearly isothermal from 4000m at 2.5°C<br>Nearly isohaline from 2000m at 35.17 |
| V | -0.4 | 400n to 7000m<br>34.92 to 34.90 | Nearly isothermal<br>Below 5500 temperature values decrease to (-0.6°C)(Arctic bottom water) |
| W | | | T°C and S 0/00 data from above 100 meters |
| X | 0.00 | 400m to 7000m<br>34.90 | Nearly isothermal from 650m at 0.0°C<br>Nearly isohaline from 410m at 34.90 |
| Y | 12.8 | 1000m to 7000m<br>38.40 | Nearly isothermal from 1200m at 12.8°C<br>Nearly isohaline from 1000m at 38.40 |
| Z | 13.5 | 1500m to 7000m<br>38.65 | Nearly isothermal from 1250m at 13.6°C<br>Nearly isohaline from 1500m at 38.65 |

TABLE IIId

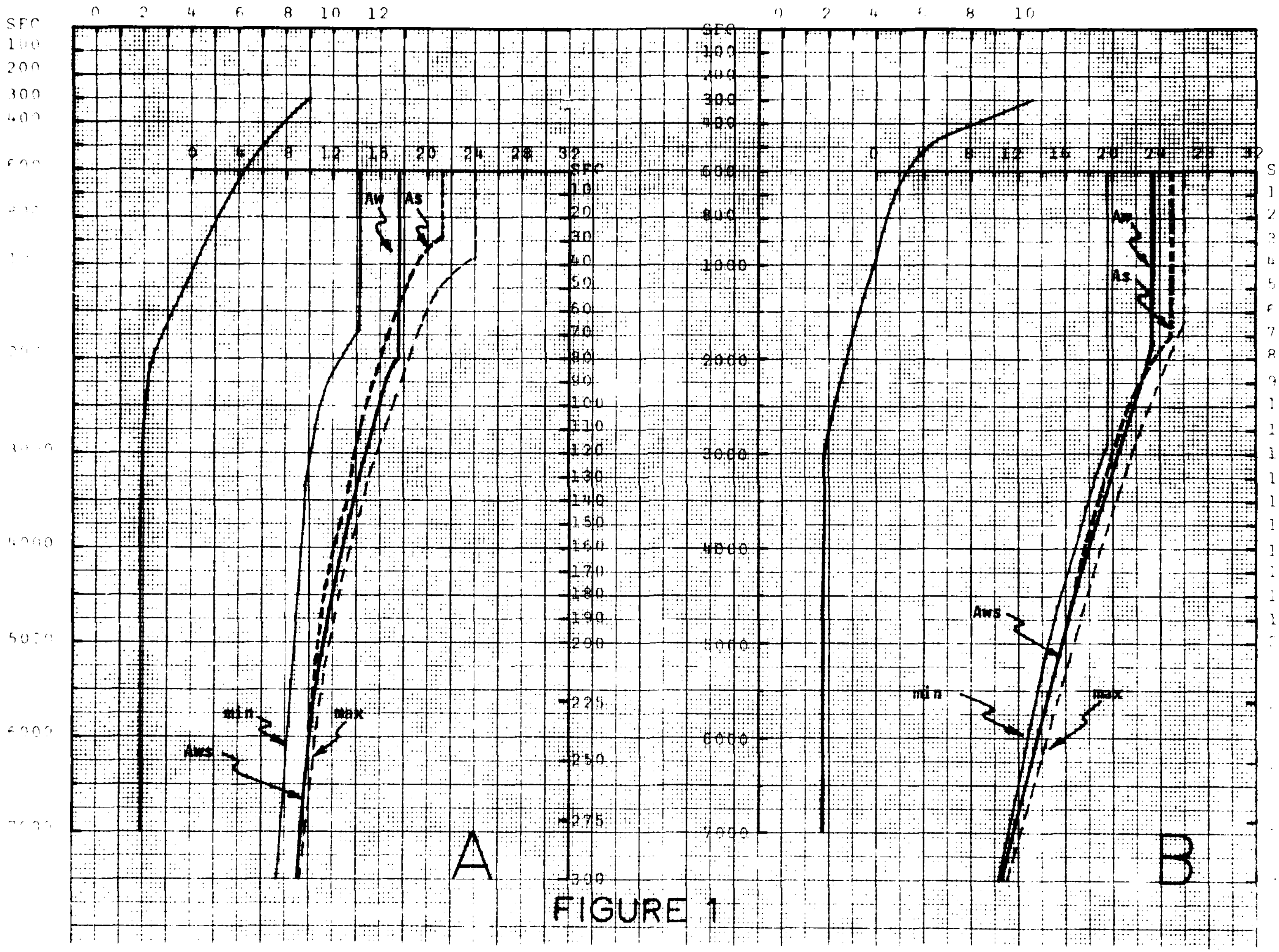



FIGURE 1

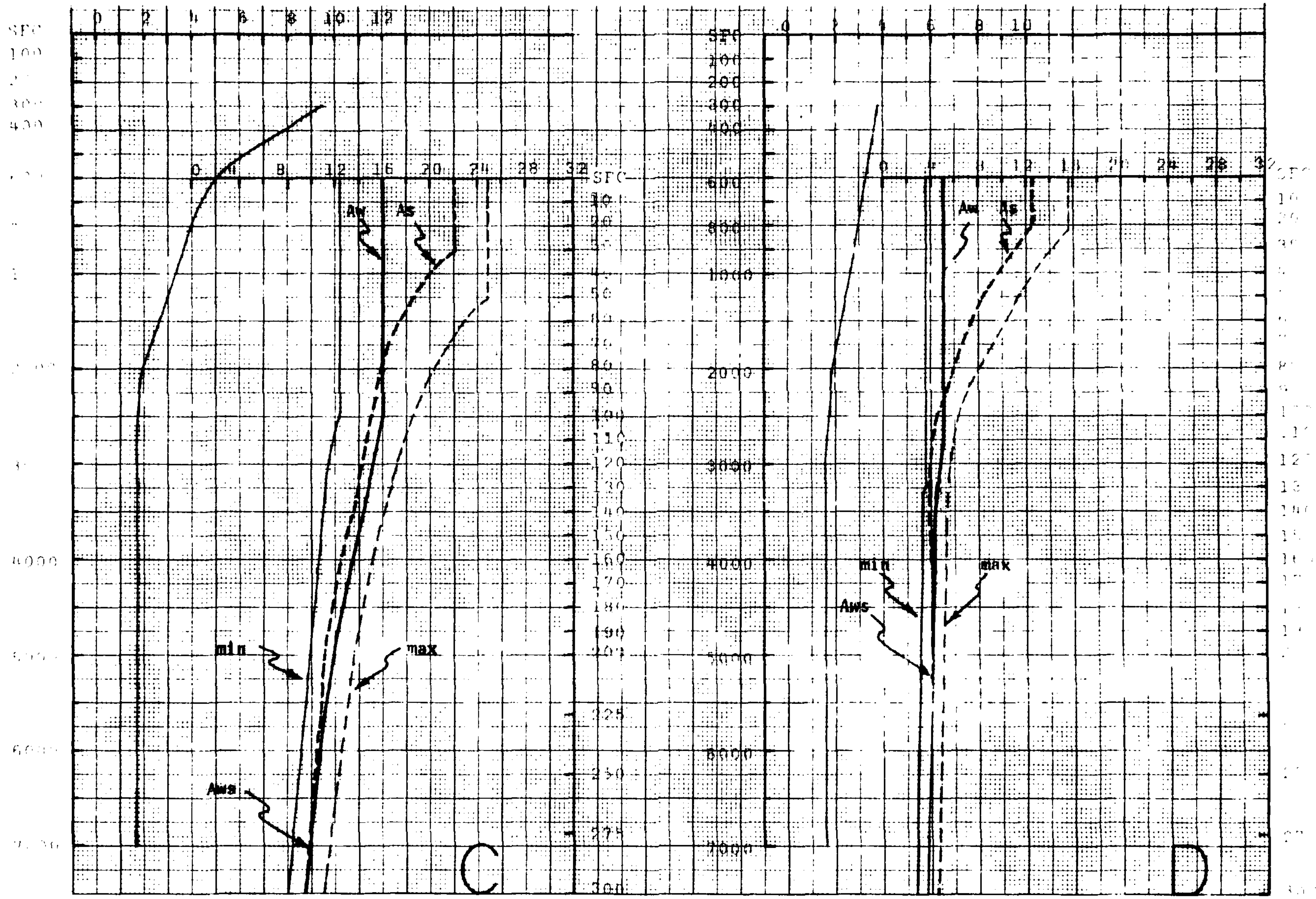



FIGURE 2

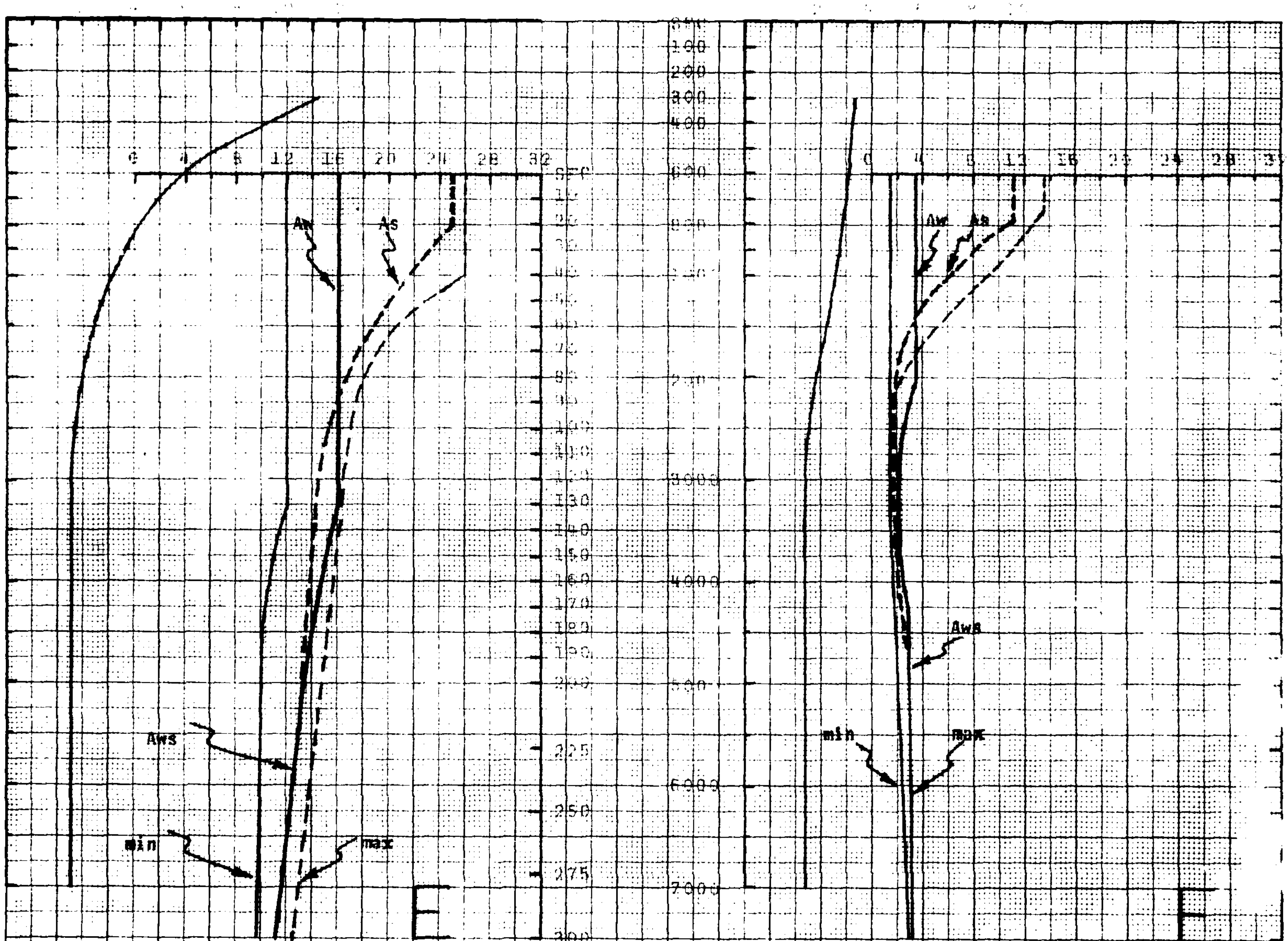



FIGURE 3

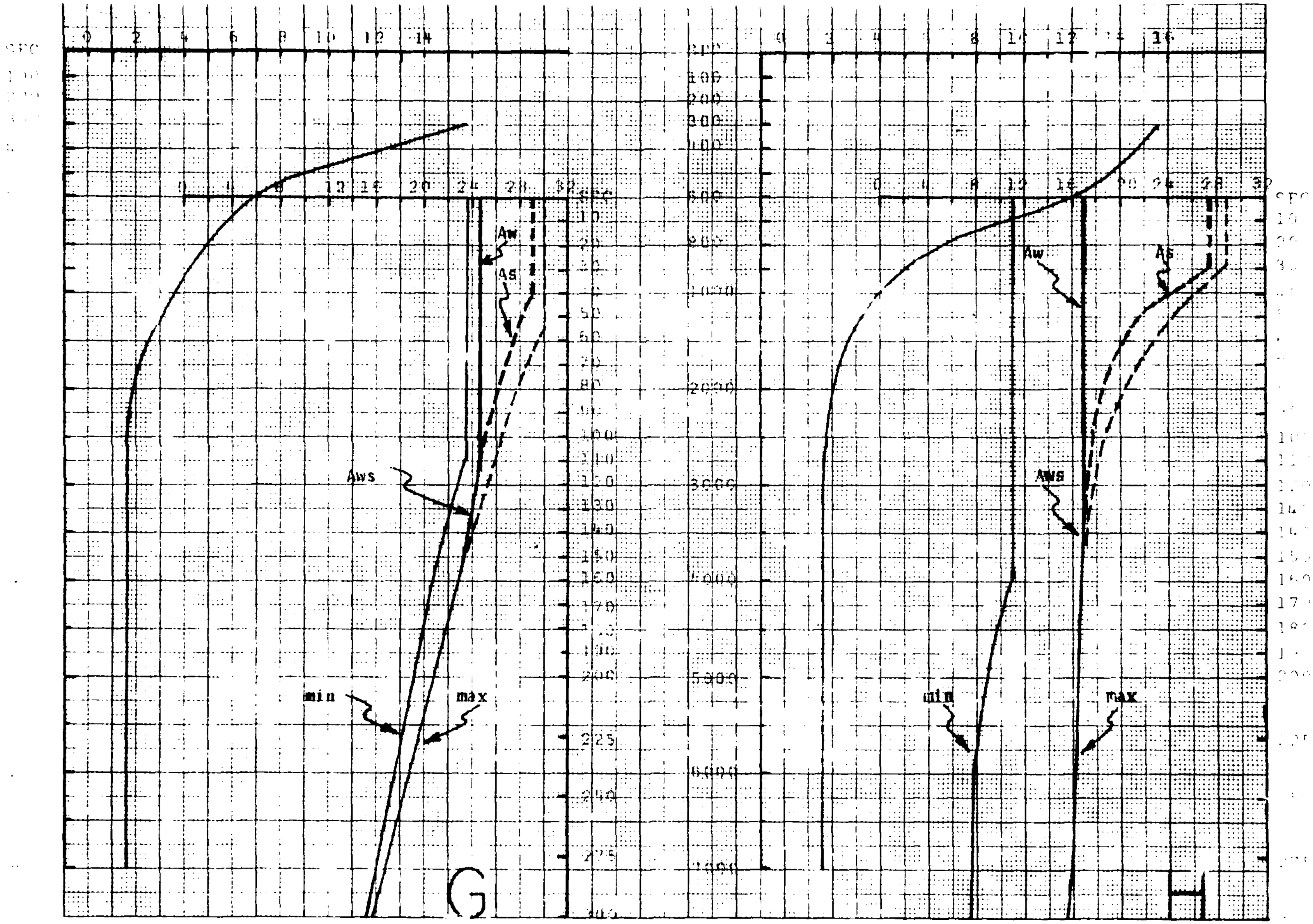



FIGURE 4

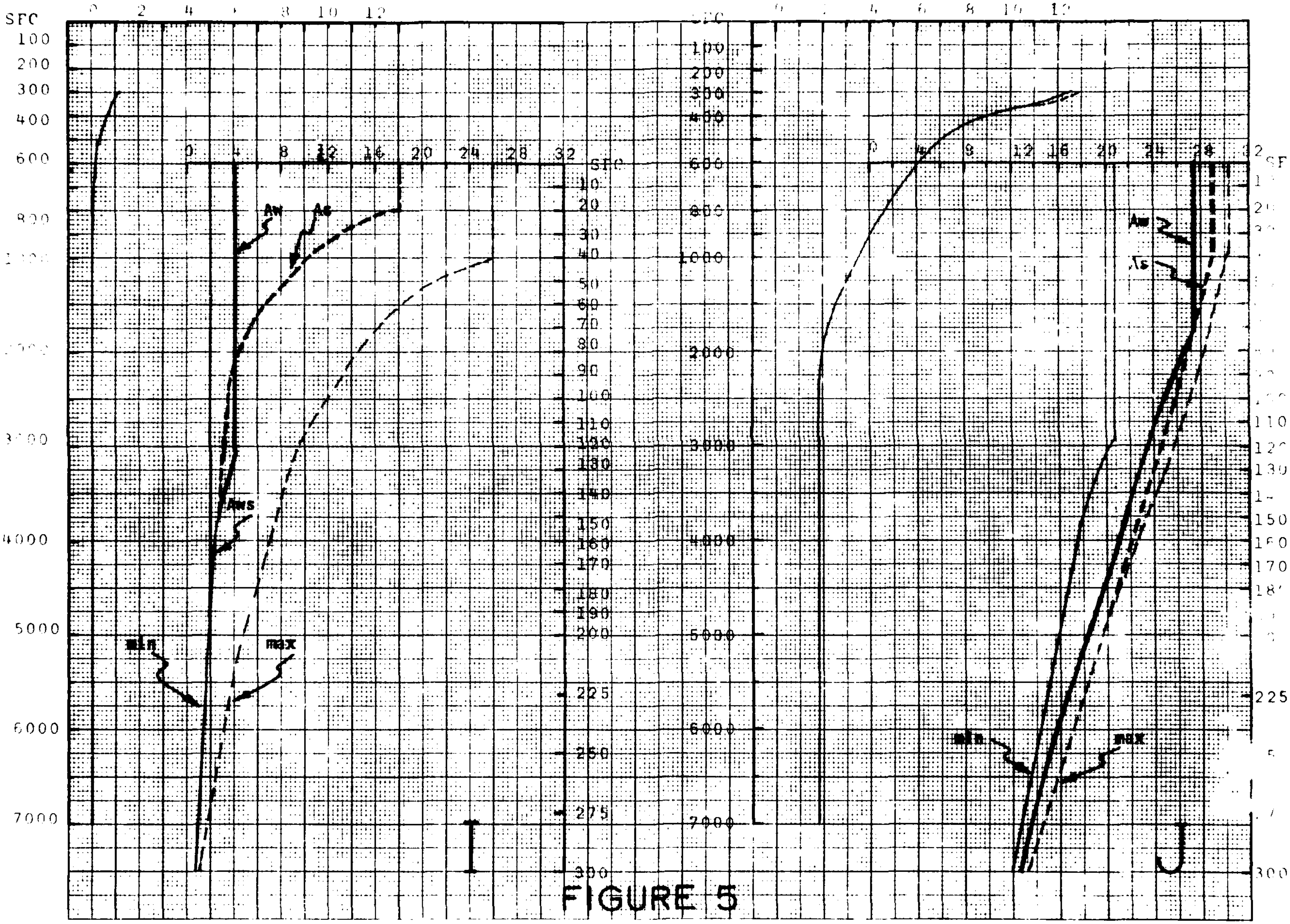



FIGURE 5

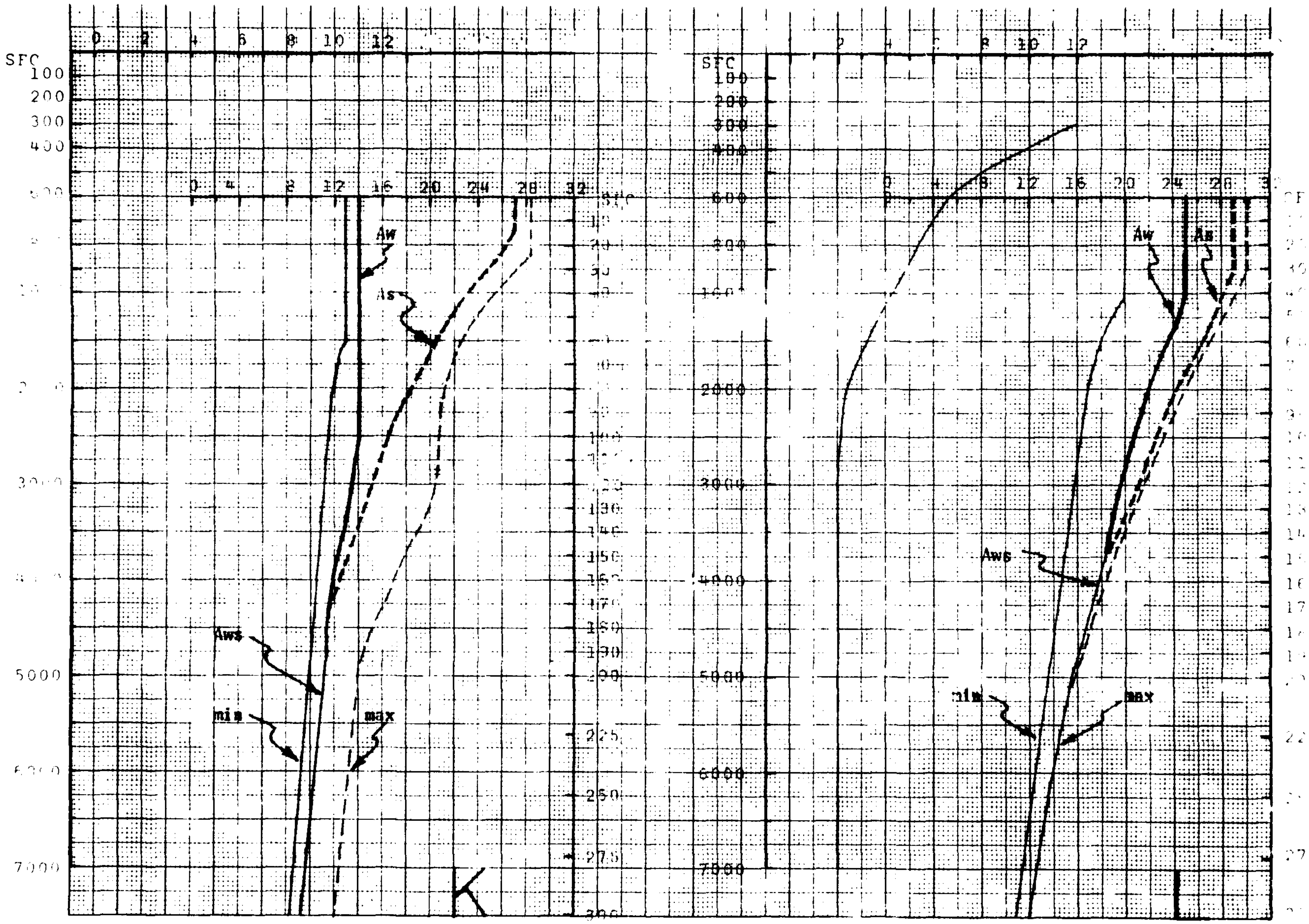



FIGURE 6

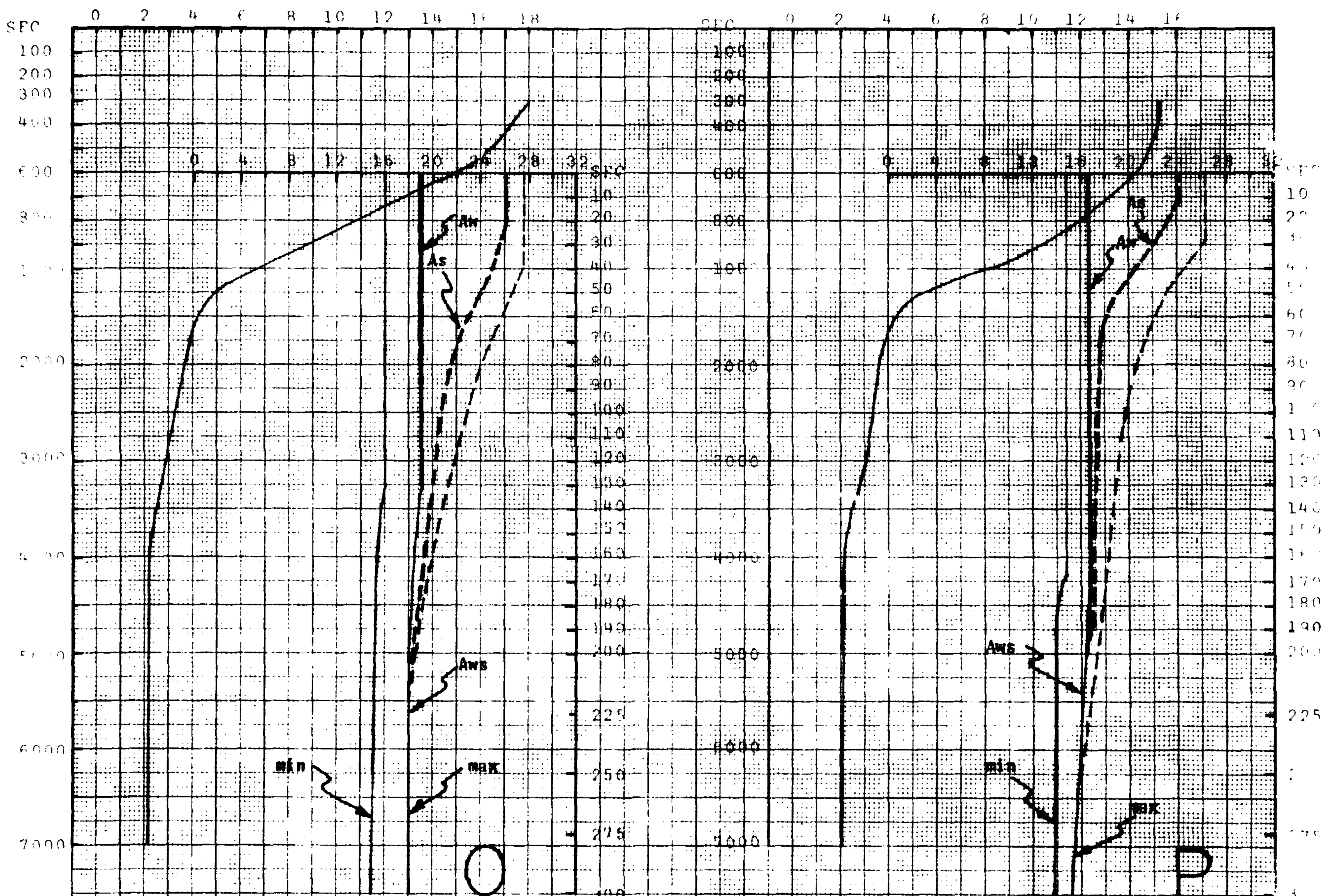



FIGURE 7

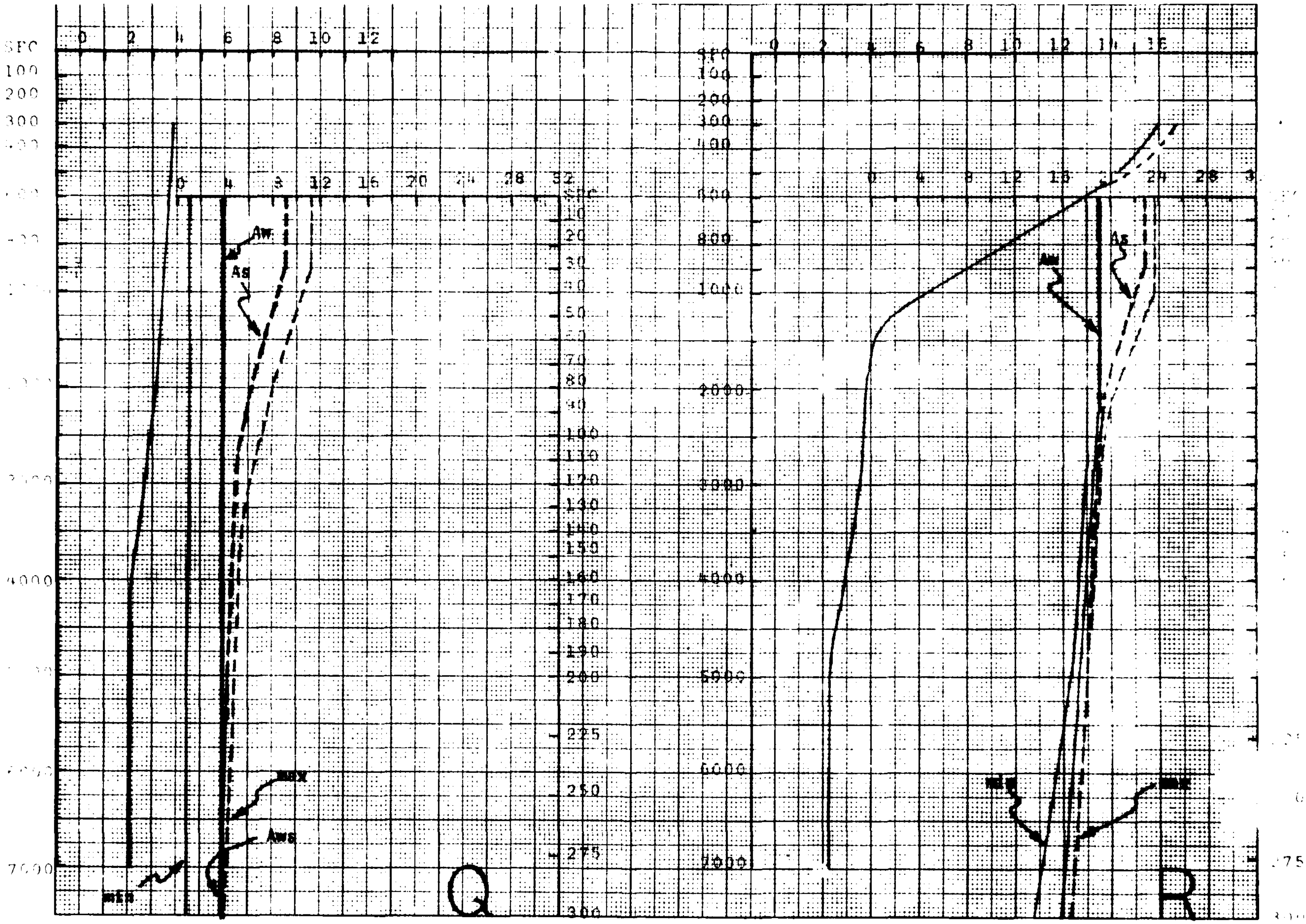



FIGURE 8

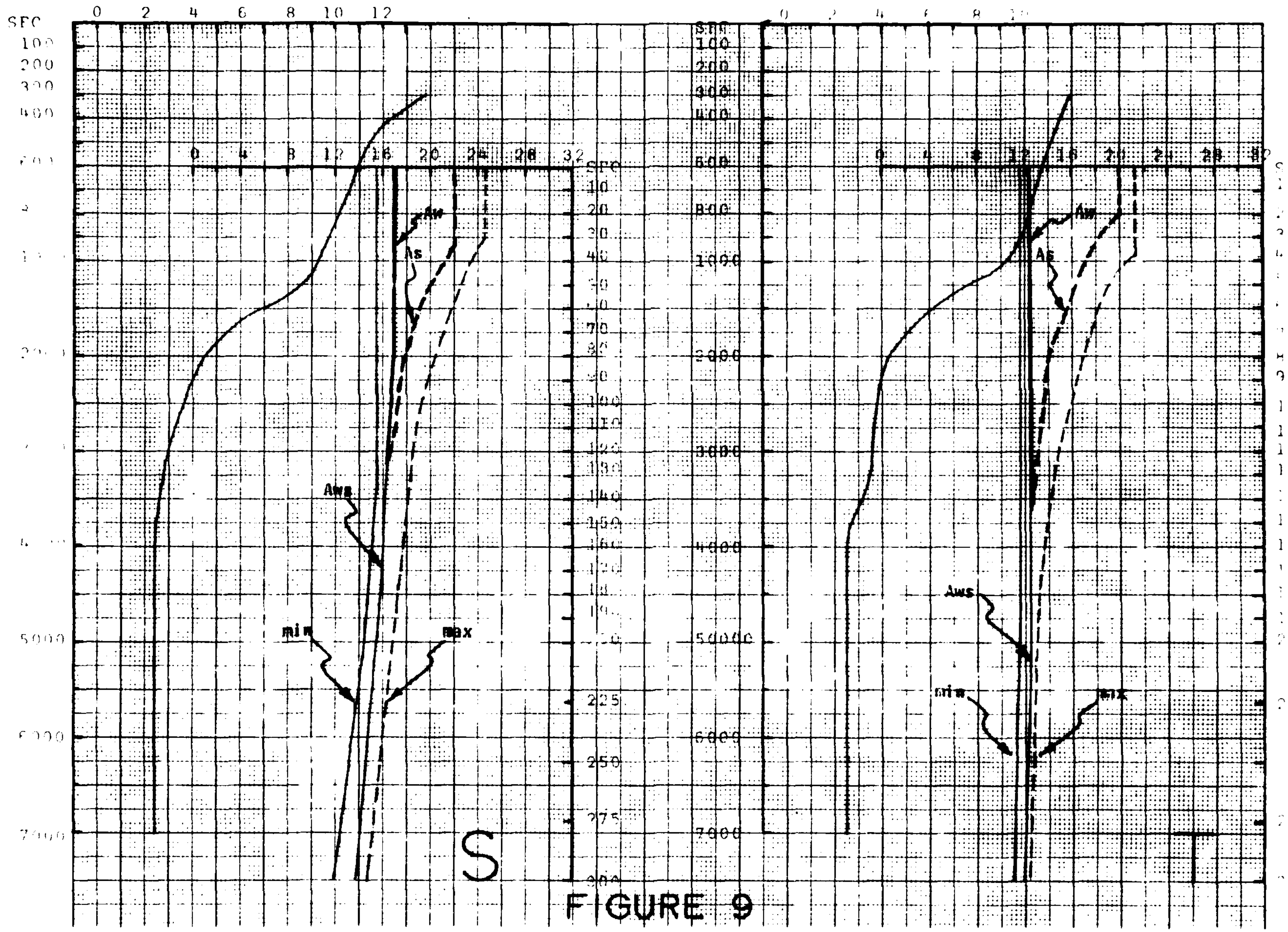



FIGURE 9

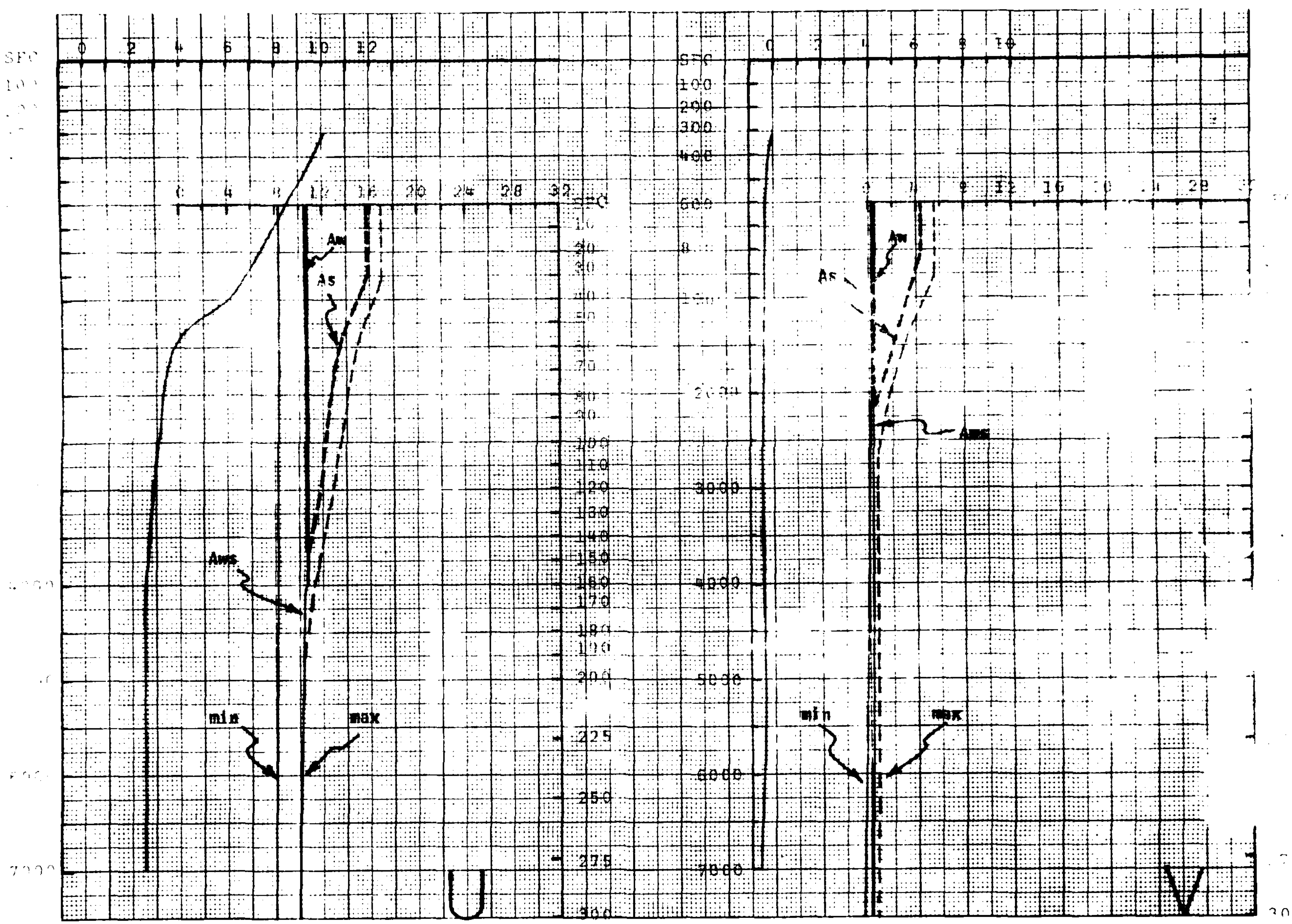



FIGURE 10

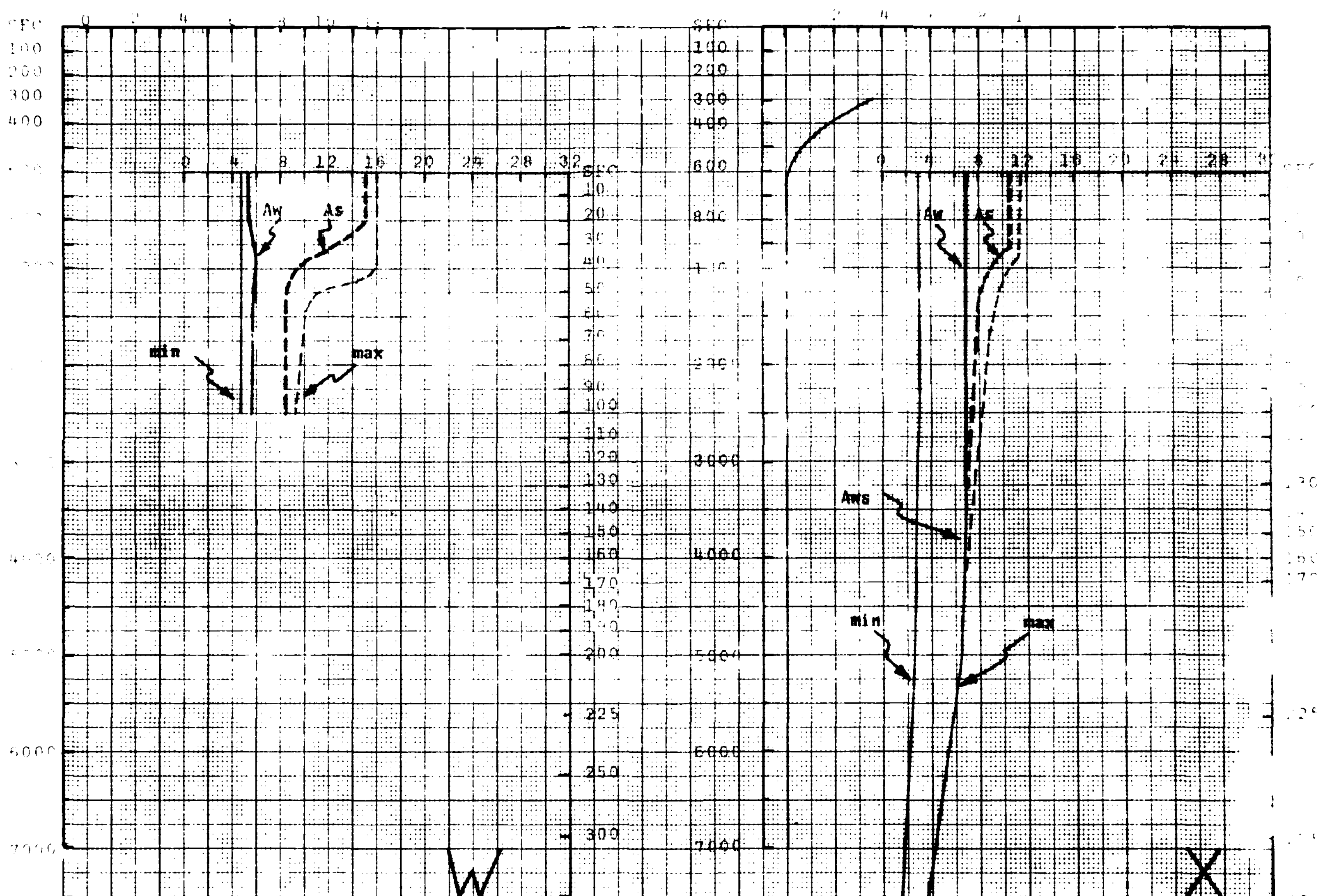



FIGURE 11

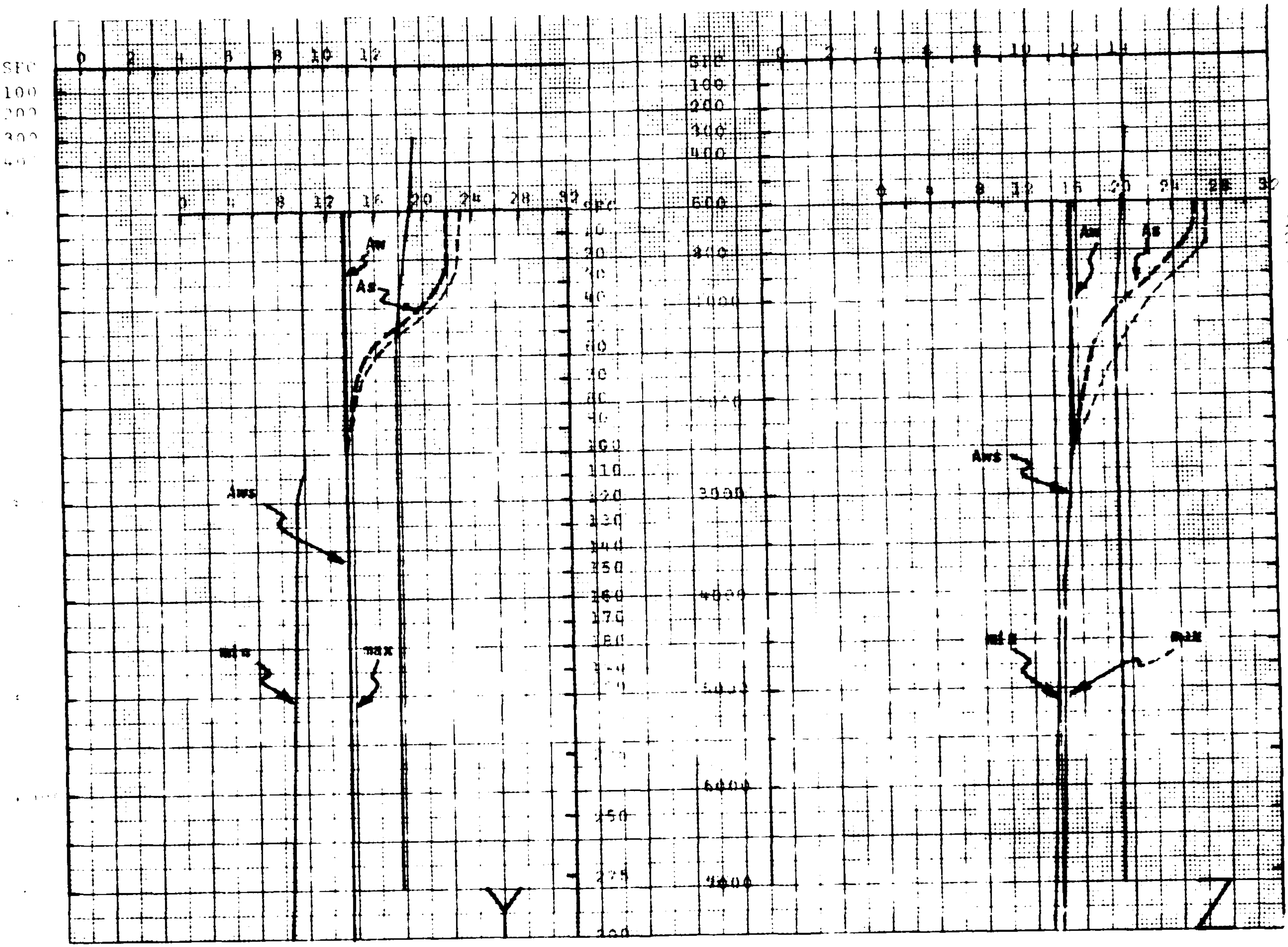



FIGURE 12

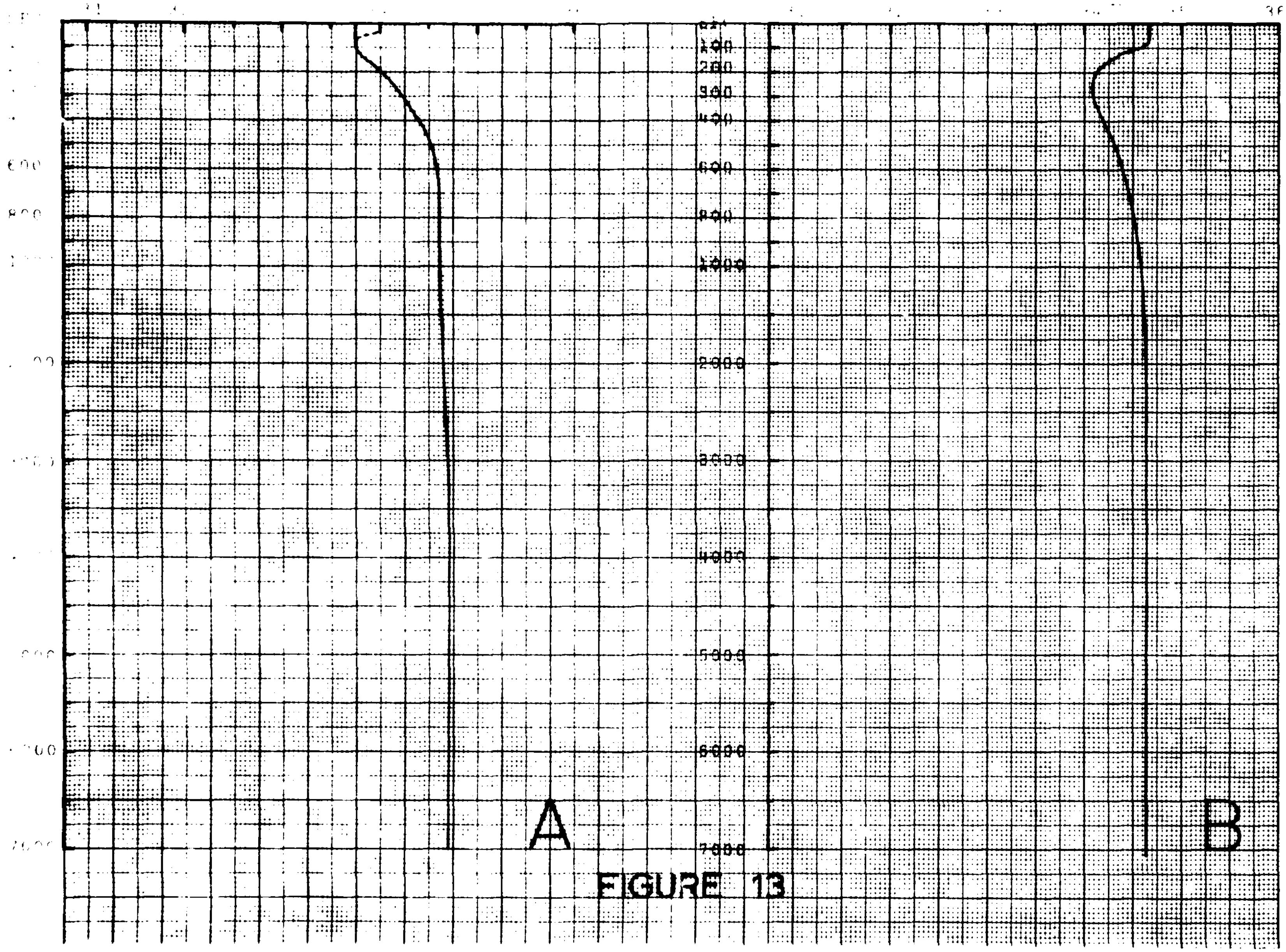


FIGURE 13

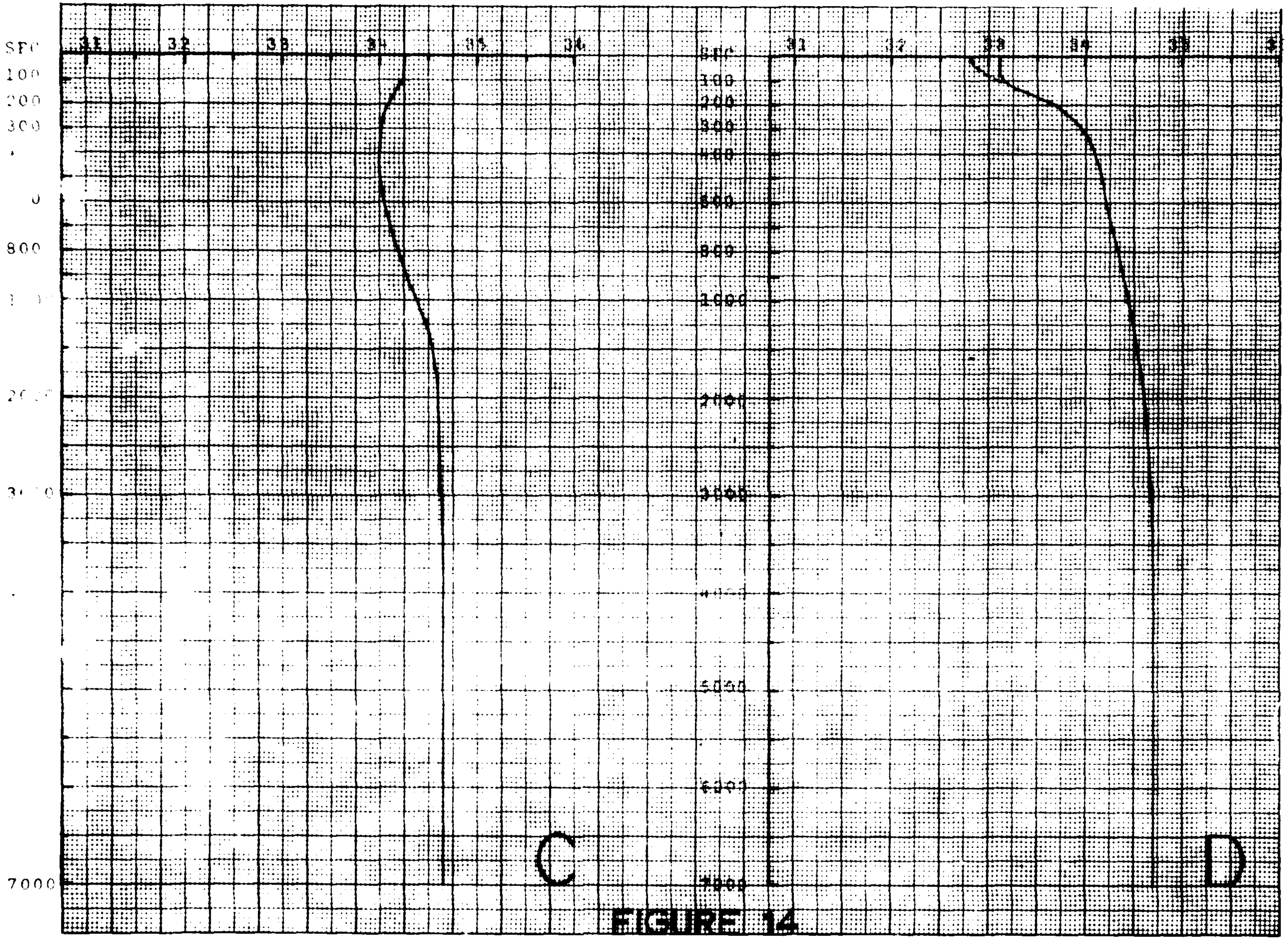



FIGURE 14

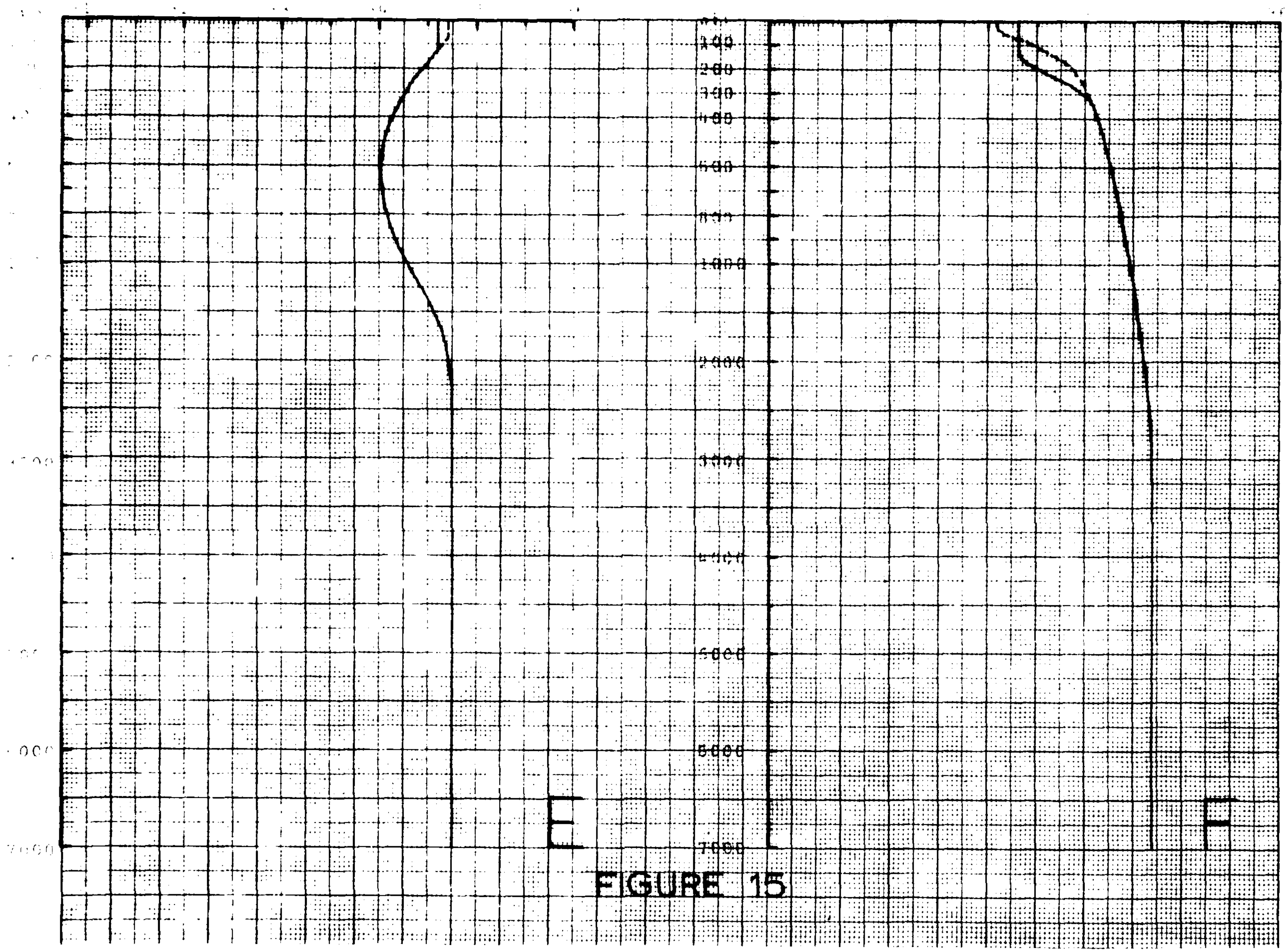



FIGURE 15

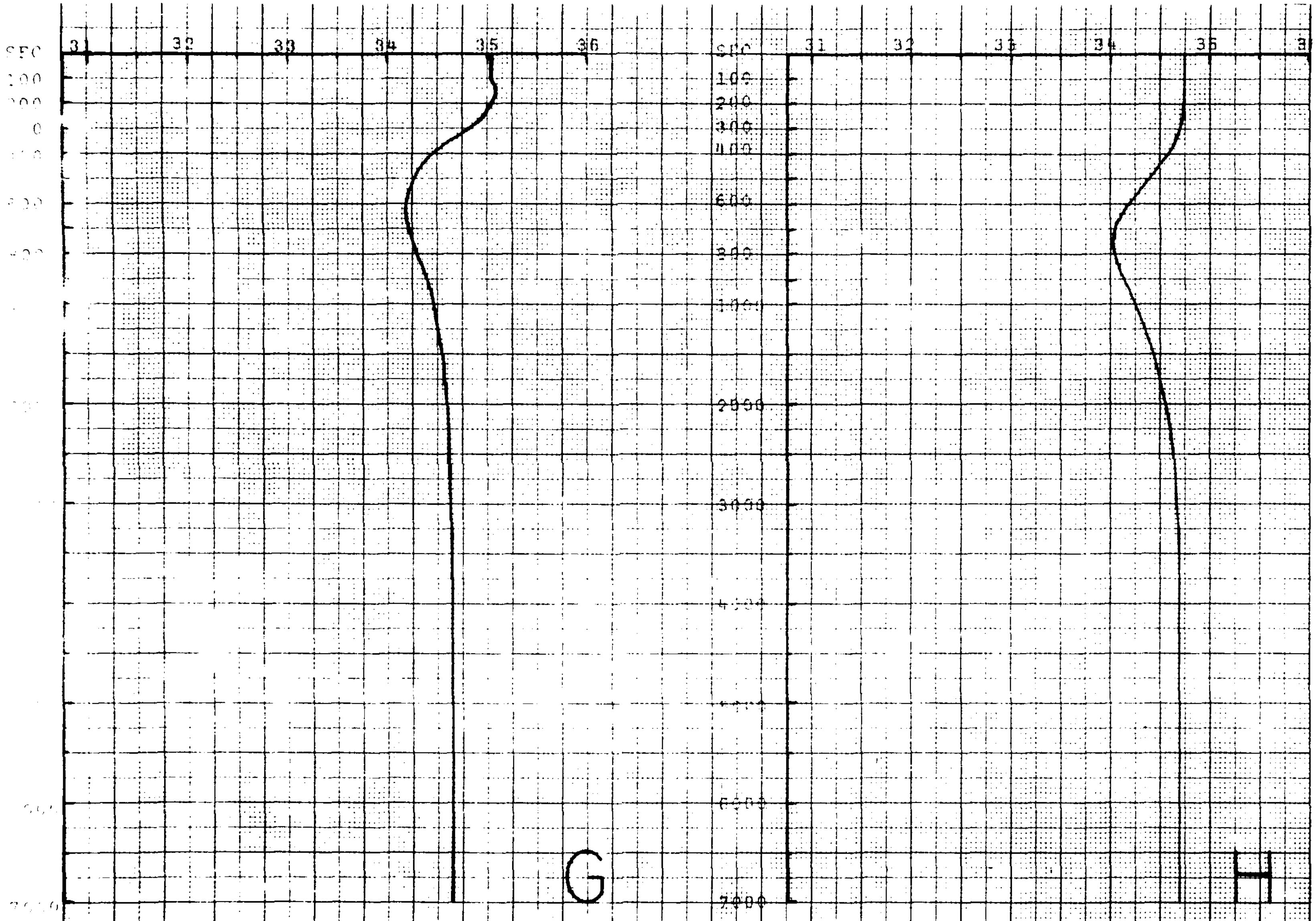

G
H
SEC
31
32
33
34
35
36
100
200
300
400
600
800
2000
3000
6000
7000

FIGURE 16

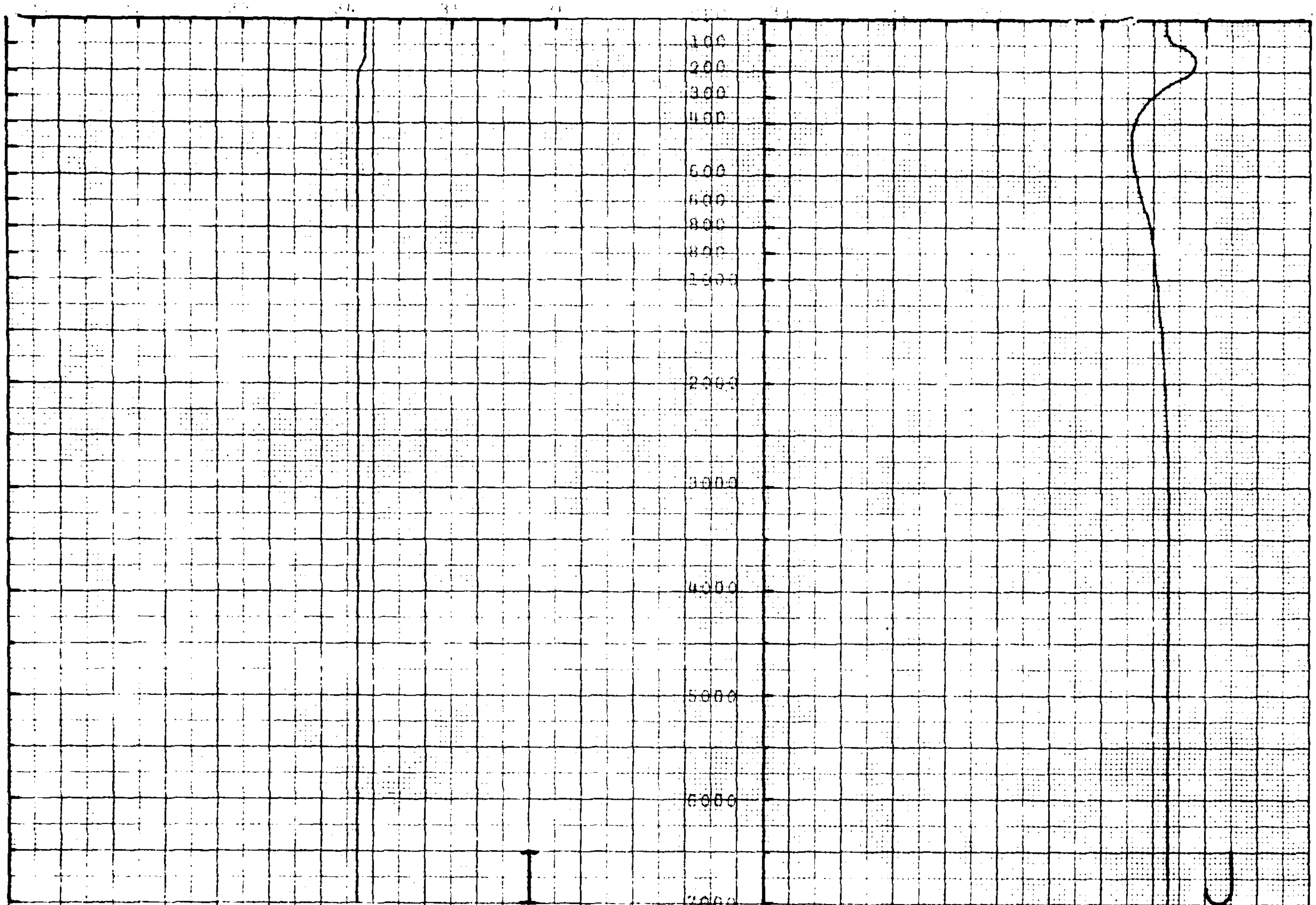


FIGURE 17

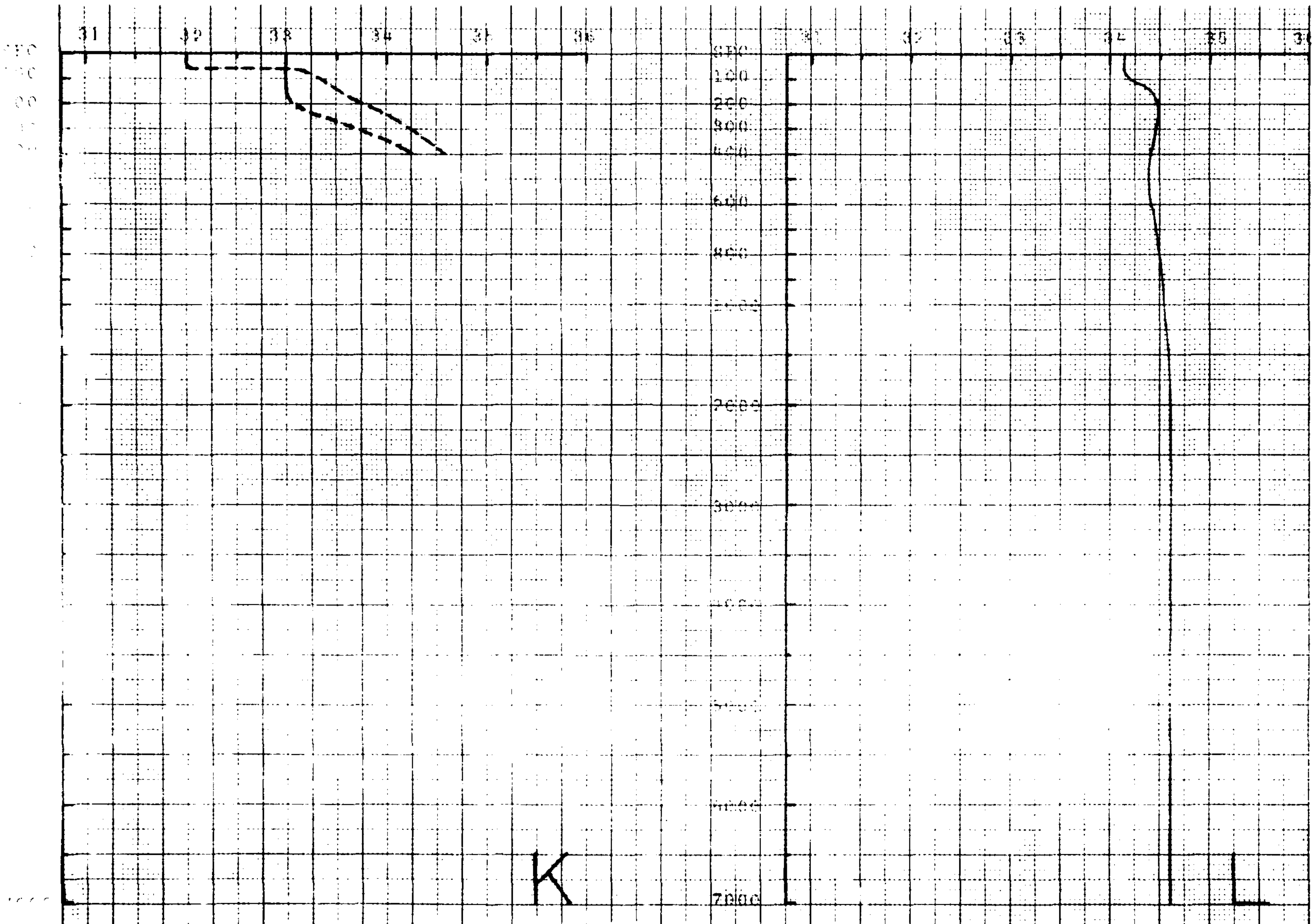



FIGURE 18

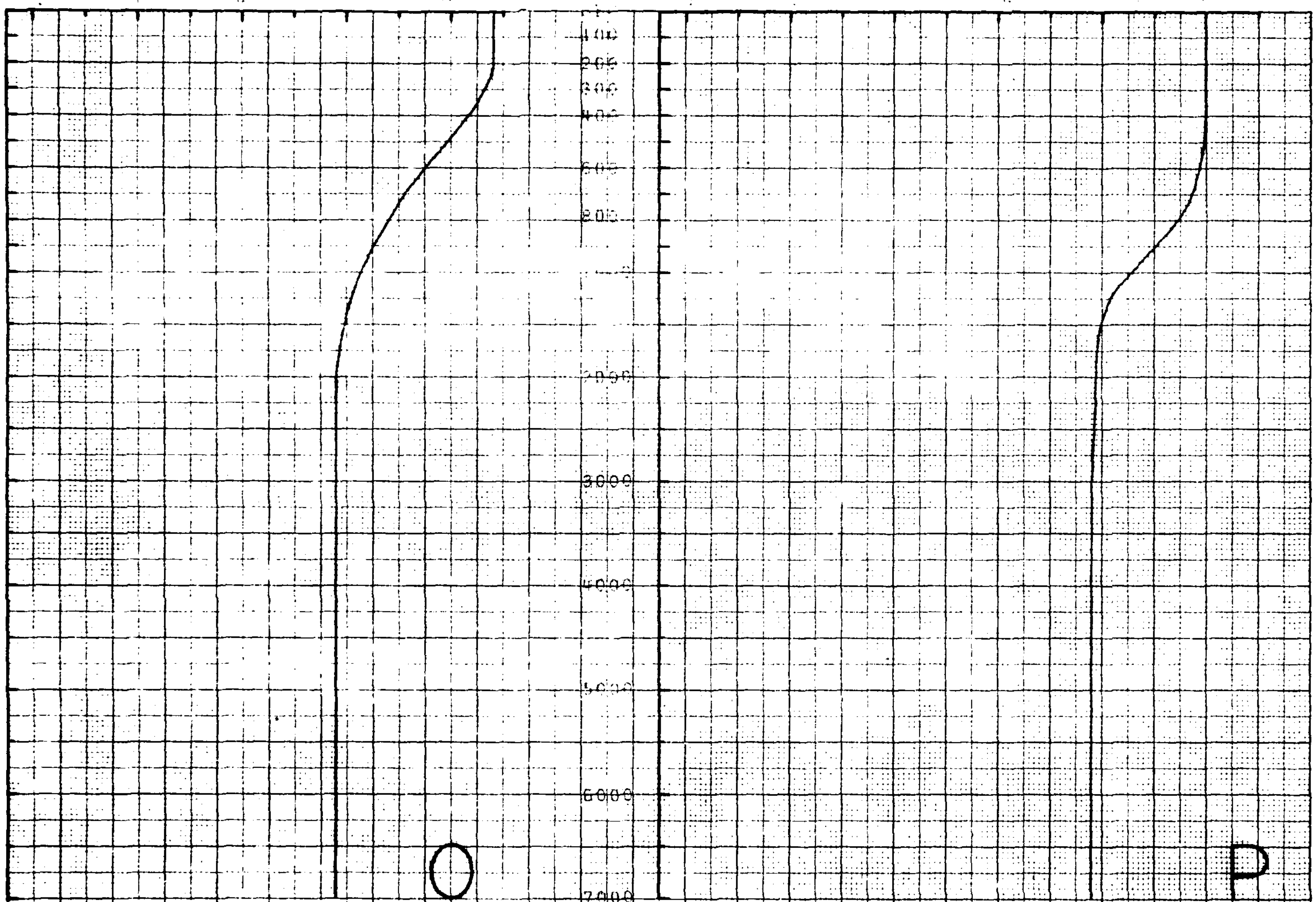



FIGURE 19

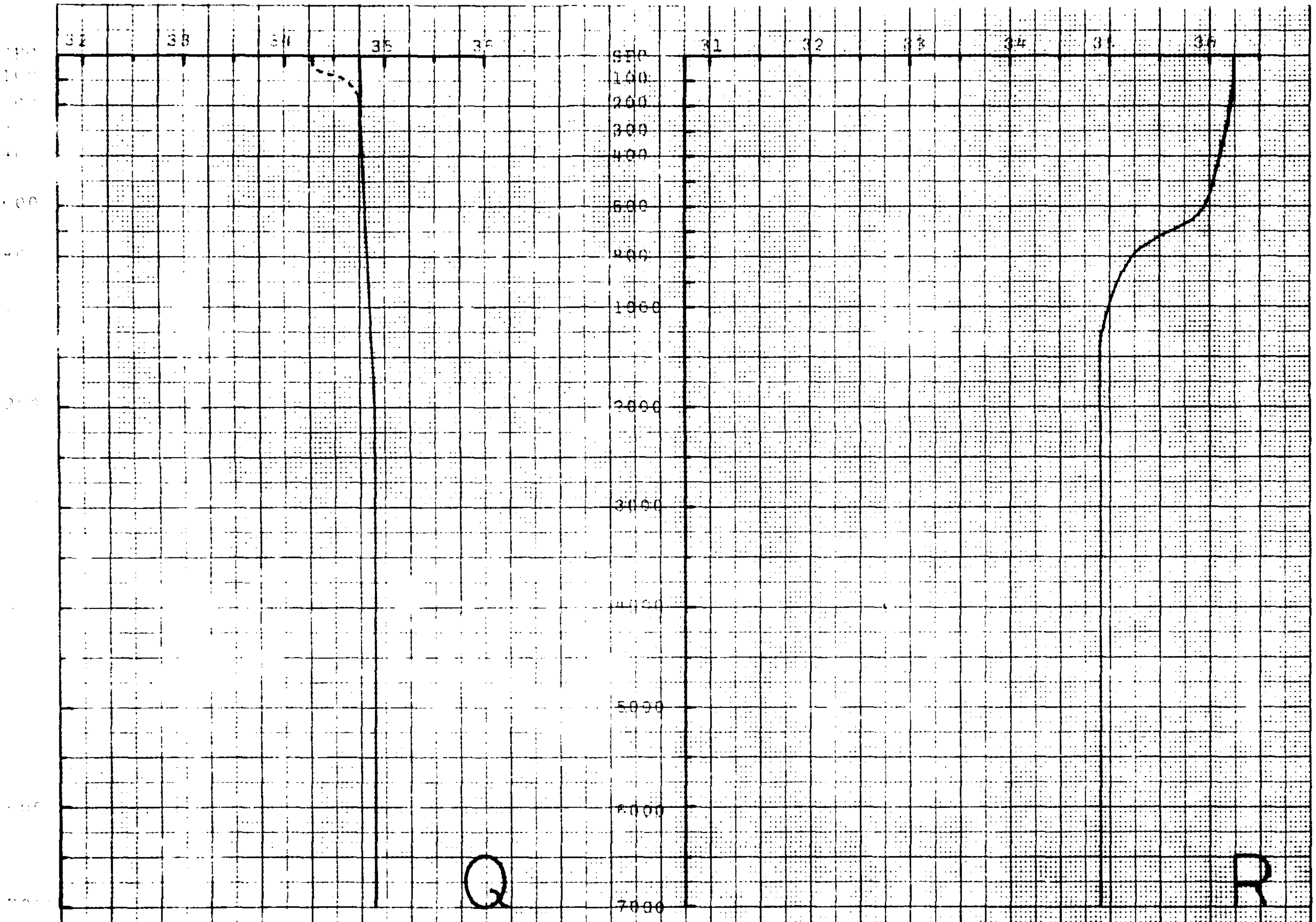



FIGURE 20

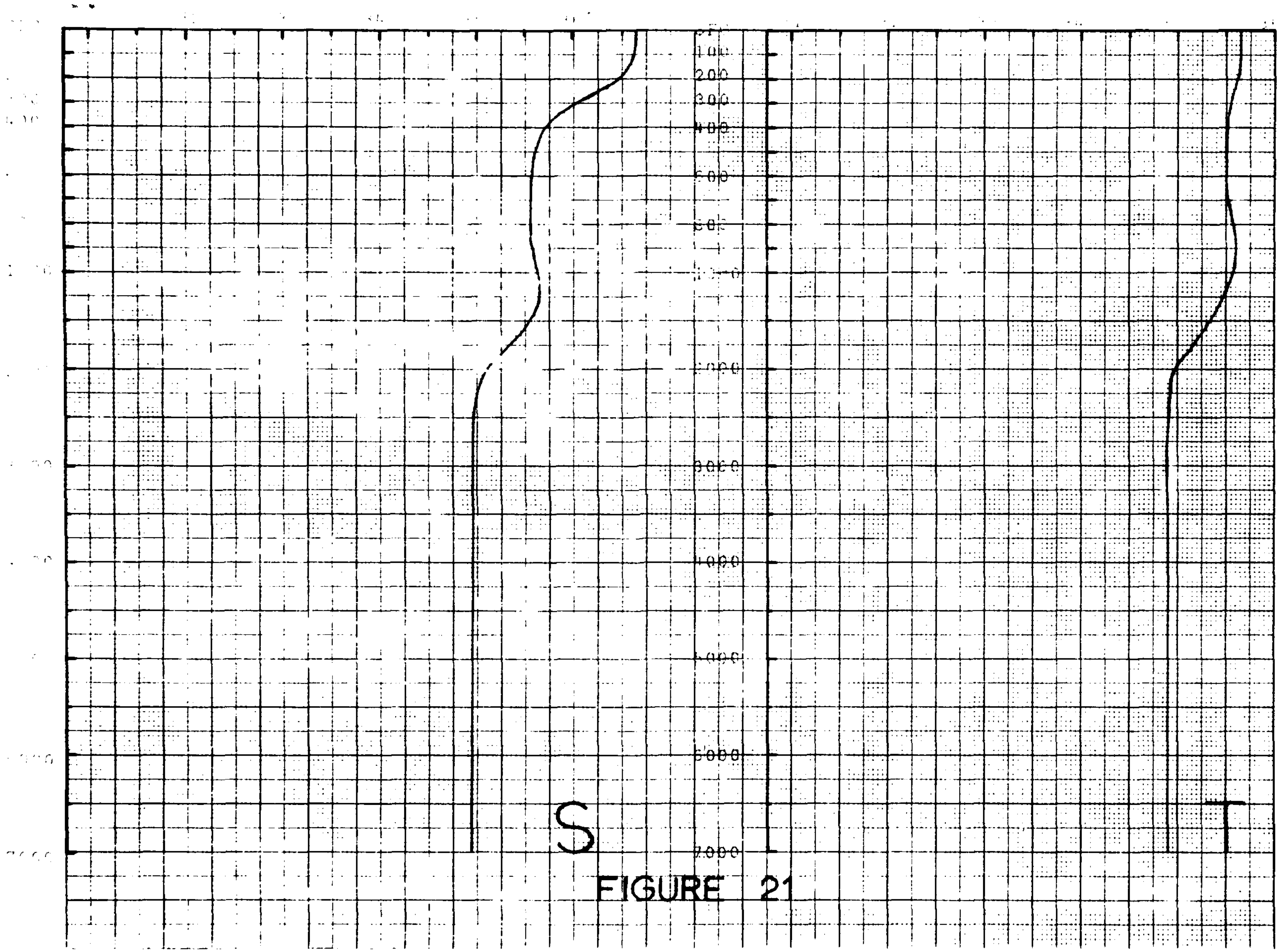



FIGURE 21

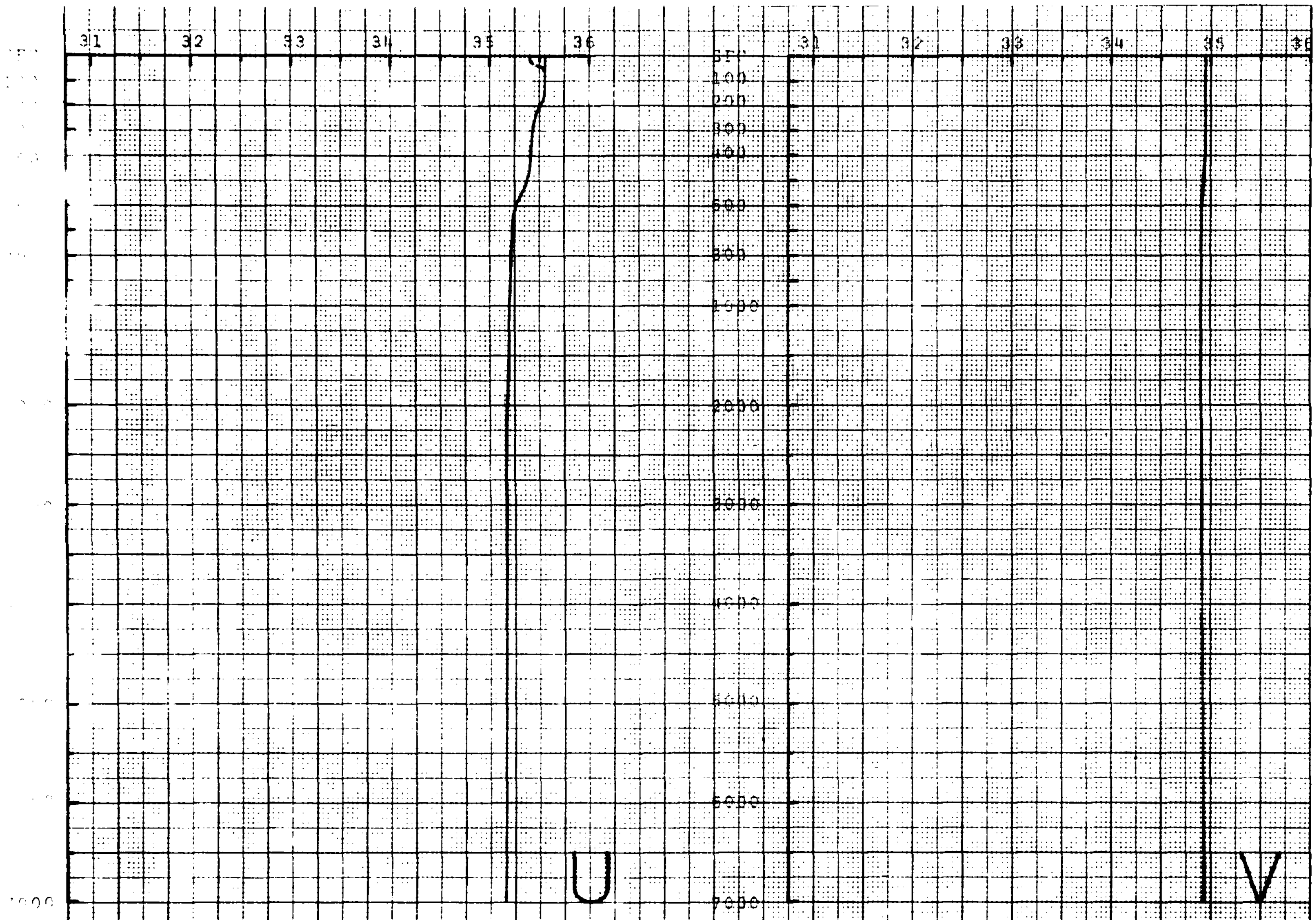

31
32
33
34
35
36
SFC
100
200
300
400
600
800
1000
2000
3000
4000
5000
6000
7000
U
V

FIGURE 22

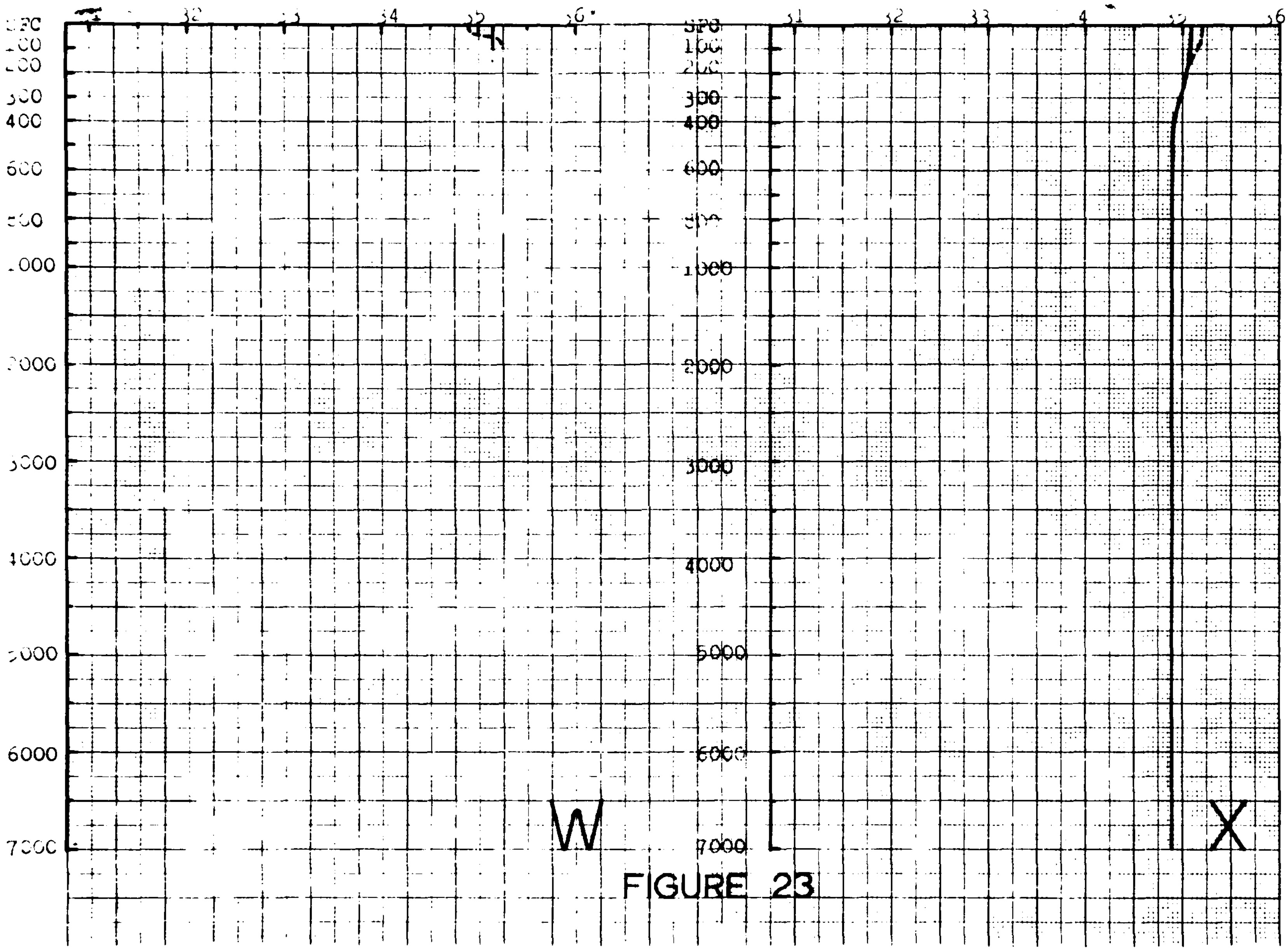



FIGURE 23

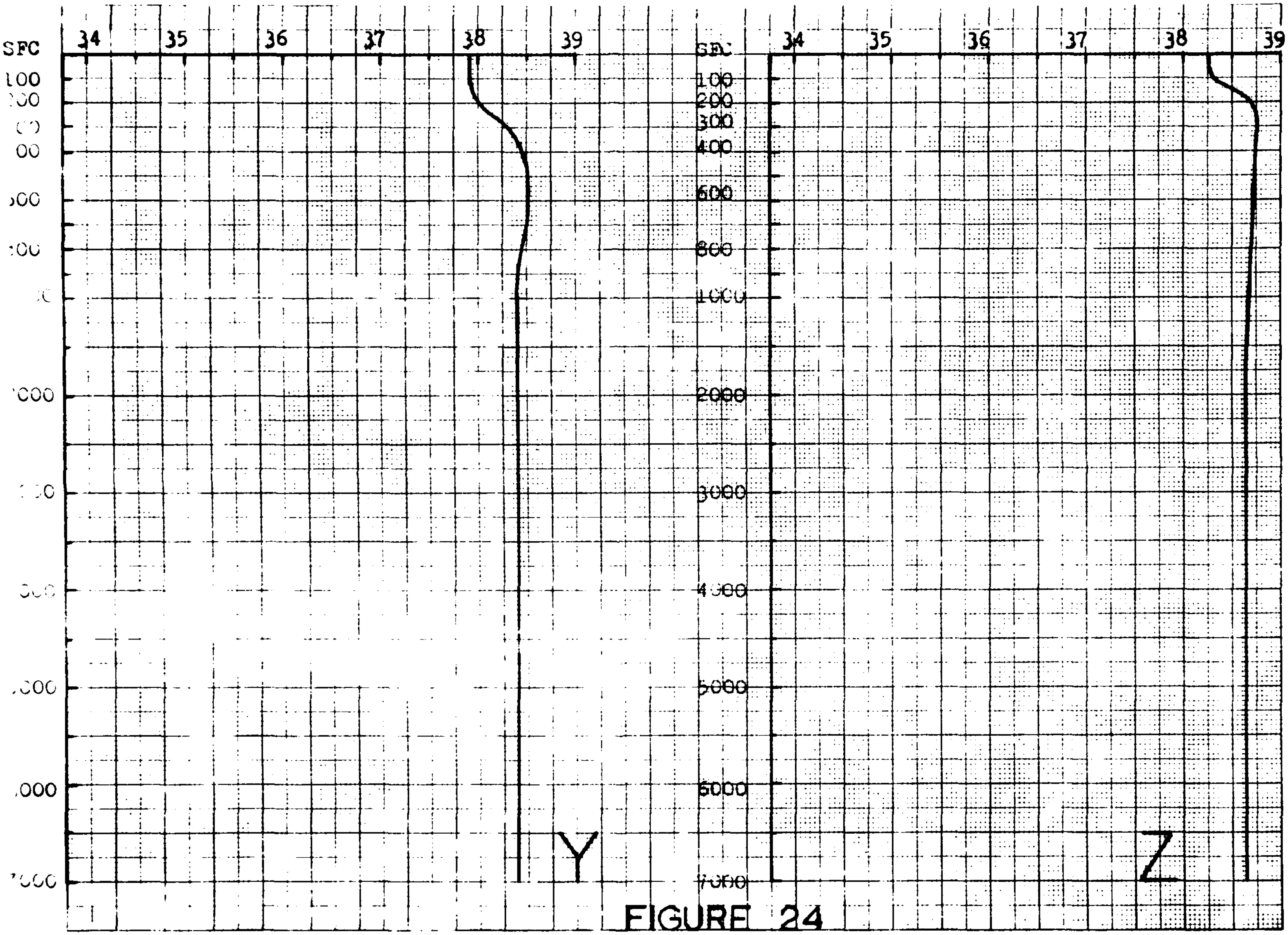



FIGURE 24

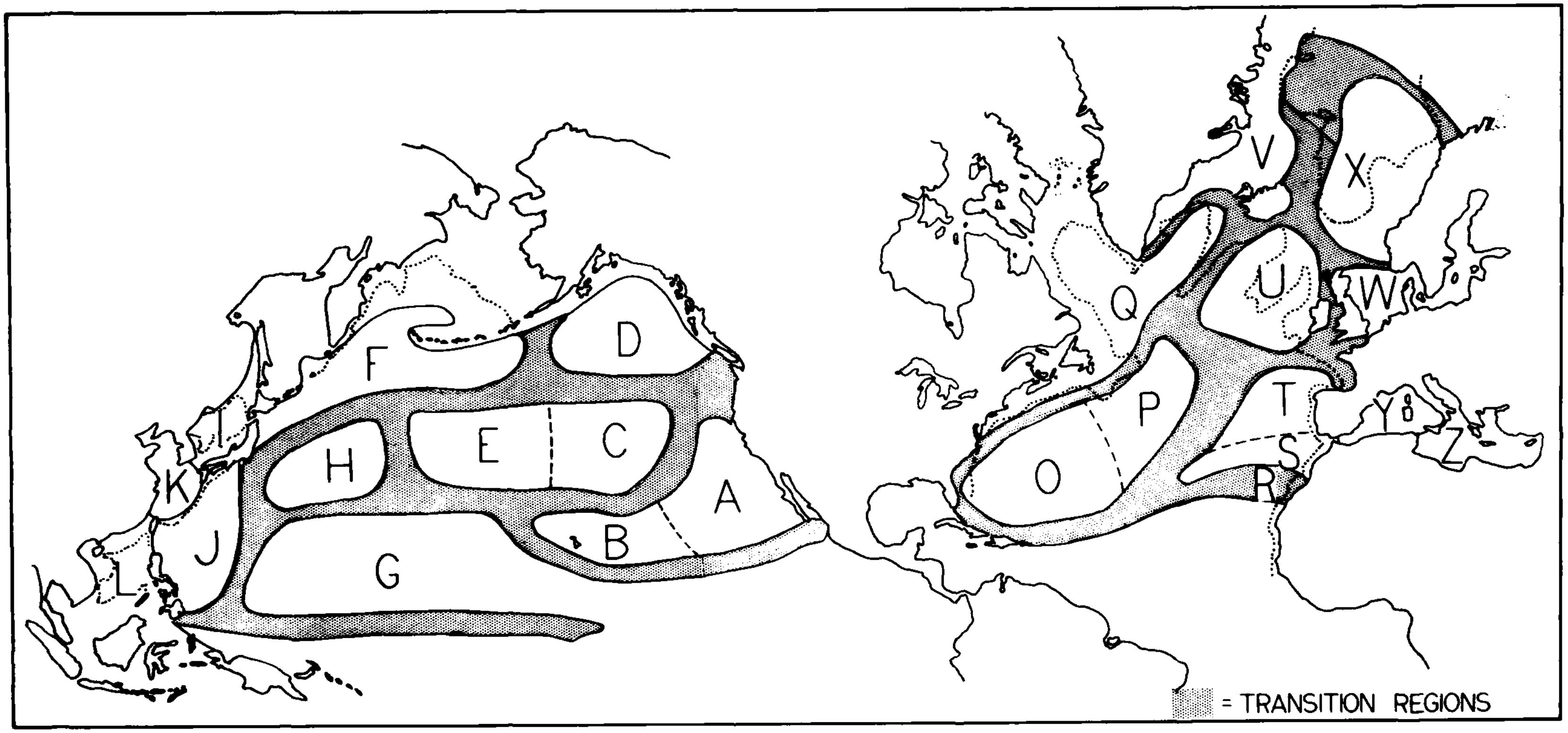



FIGURE 25 MAJOR NATURAL OCEANOGRAPHIC PROVINCES AND THEIR TRANSITION REGIONS

Distribution: FNWCINST 5216.1, 14 Feb 68

| | |
|---|---|
| List I | B, D |
| List II | S, T, U, V, W, X |
| List III | D, E, F, H, I |
| List IV | A, B, C, D, E, F |
| List V | A, B, C, D, E, F, G, H, I, J |
| List VI | A, B, C, D, E |
| List VII | A, D, E, F, N, O, P, Q, T, W |
| List VIII | D, E, F, G, H, J, K, L, M, N, O, P, Q |
| List IX | B |
| List X | E |
| List XI | B, E, H, J, K |
| List XII | A, E, G, H, J, L, M, P, S, U, V, X, Z, C1, J1, Q1, D2, E2, G2, H2 |

E

ED

80